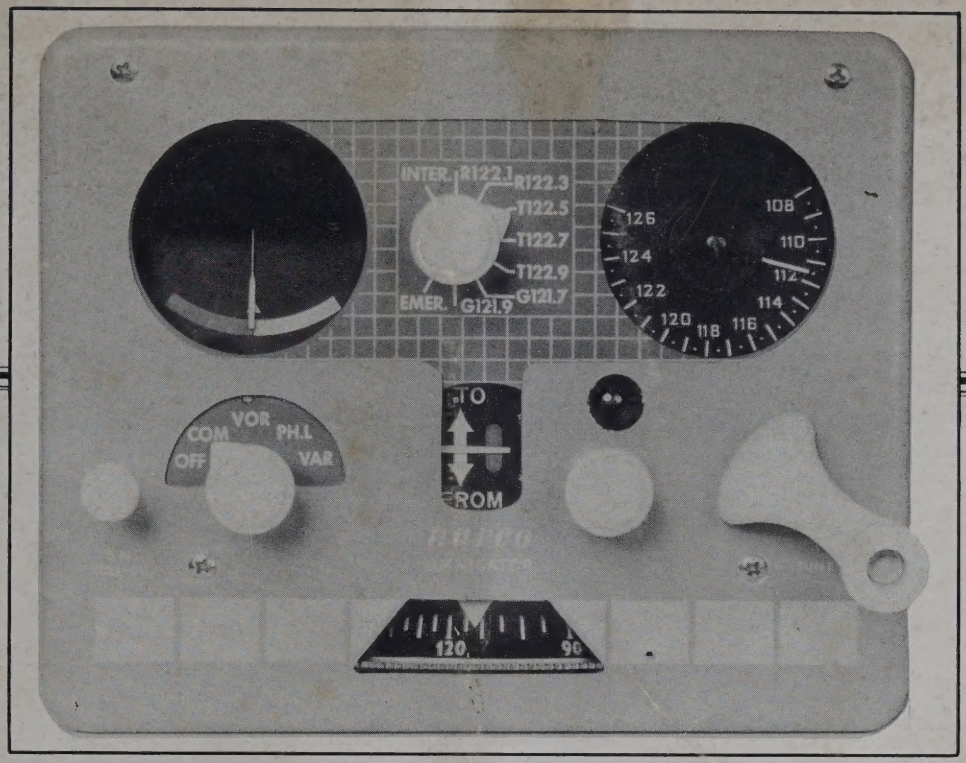

The narco VTR-1 OMNIGATOR

with V12MP-2 POWER UNIT

•

OPERATION · INSTALLATION and SERVICE MANUAL

•

MANUFACTURED BY

NATIONAL AERONAUTICAL CORPORATION

WINGS FIELD · AMBLER · PENNSYLVANIA

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Perfection in Electronics

Price $1.00

Warranty

We have designed and constructed this equipment using the finest materials and components available. It has been thoroughly tested and inspected before leaving our factory.

NARCO warrants your new VTR-1 and V12MP-2 against all defects of workmanship and material on components and parts manufactured by us for a period of ninety (90) days from the date of installation. We will furnish a new part in exchange for any part which proves to be defective within this time under normal installation use and service provided you return the defective part, transportation charges prepaid, either to the factory or to our authorized Warranty Service Center.

To place your warranty in effect you must fill out the warranty card supplied with the set, and mail it to us within ten (10) days after your new installation is completed.

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Section I ·· Operation

A. RECEIVER

A-1. FUNCTION SWITCH

The five-position rotary switch on the lower left part of the front panel turns the power to the entire set OFF and ON, and serves to set up the set for the desired type of operation. Its positions are:

1. OFF — All power to set and power unit shut off.
2. COM — For communication use.
3. VOR — For Omni-Range operation.
4. PH. L — For Phase localizer approach.
5. VAR — For Tone localizer approach and navigation by Visual-Aural Range system.

A-2. TUNING DIAL

The dial is calibrated directly in megacycles from 108.0 to 126.5. Stations are tuned in the customary manner. The tuneable frequency band is divided as follows:

1.	108.1 to 111.9	Airways Communications stations VHF Radio Ranges (VAR). Phase and Tone localizers.
2.	112.1 to 117.9	Omni-Range stations.
3.	118.1 to 121.3	Control-Tower stations.
4.	121.5	Emergency channel.
5.	121.7 to 121.9	Ground Control stations.
6.	122.1 to 122.9	Private Aircraft stations.
7.	122.8 (UNICOM)	Private Aircraft Control stations.
8.	123.1 to 123.5	Flight Test; Flying School stations.
9.	123.7 to 125.5	Approach Control stations.
10.	125.7 to 126.5	Air Carrier stations.
11.	126.18	Military Tower frequency.

The voice channel of the localizer stations carries a frequent station identification and in some cases also the control-tower voice transmissions. It is intended that eventually all localizers will carry the tower voice transmissions.

The voice channel of the omni-range stations carries a frequent station identification and also the usual range-station communications such as airways traffic control, weather information, etc.

The control-tower stations function in a manner similar to low-frequency towers providing communication relative to take-offs, landings, etc.

A positive stop is provided at each end of the tuning range. Damage may result if the tuning crank is forced beyond the stops.

A-3. VOLUME CONTROL

The receiver volume control is used to set the desired loudness level of the voice signals. It does not affect the navigational functions, nor the loudness of the marker beacon tones.

A-4. MARKER BEACON RECEIVER

Operation of the 75-mc. marker beacon receiver is controlled by a push-pull switch located on the front panel to the left of the FUNCTION SWITCH. Pull the knob out about 1/8" from the panel to activate the marker receiver. The settings of the volume control and function switch (other than OFF) do not affect the operation of the marker receiver.

B. TRANSMITTER

B-1. CHANNEL SELECTOR

The channel selector is in the upper center part of the panel. It has 9 positions as follows:

1. INTER	Interphone operation (set does not transmit).
*2. R-122.1 3. R-122.3	VHF Airways Communications stations.
*4. T-122.5 5. T-122.7 6. T-122.9	VHF Control-Tower stations.
7. G-121.7 8. G-121.9	Ground Control stations.
9. EMER(121.5)	Emergency calls ONLY.

* Crystals for these channels are supplied with equipment. See paragraph IV-D.

The channel marked EMER (121.5) is set aside for emergency use exclusively. No other communication may use it. Thus a pilot may be sure that a clear calling channel is available to him for use should the occasion arise which demands it.

B-2. MODULATION

The push-to-talk switch which is part of the microphone serves to place the transmitting equipment in operation. The transmitter will operate in any (but OFF) position of the FUNCTION SWITCH, but the "COM" position is recommended for fastest receiver recovery after a transmission.

The front panel also includes a transmitter output lamp. This lamp is lighted by a portion of the transmitter output power and serves as a positive indicator of actual transmission. It will light whenever the transmitter is radiating, but will not respond when the selector switch is in the INTER position or is set to inactivated channel. This indicator lamp should flash somewhat brighter, in rhythm with the voice, when speaking into the microphone, and in so doing serves to inform the pilot that his microphone is functioning, and that he is speaking loud enough and sufficiently close. Failure of the lamp to brighten when speaking therefore indicates one or more of the following shortcomings:

1. Pilot not talking loud enough.
2. Microphone too far away from his mouth.
3. Microphone not functioning properly.

The range of reliable VHF radio transmission is limited by the approximate distance to the horizon. Therefore, the reliable range increases rapidly as higher altitudes are attained. The table below will provide a basis for estimating the reliable range at various altitudes in flat country.

Altitude	Range in Miles	Altitude	Range in Miles
Zero	15	5000 ft.	60
1000 ft.	25	7500 ft.	70
2500 ft.	40	10,000 ft.	75

In mountainous country the reliable range depends upon a clear line of sight unobstructed by intervening mountains between the airplane and the ground receiving station.

B-3. LICENSE NOTICE

The operation of this radio transmitting equipment requires at least a third-class radio telephone operator's license.

C. OMNI-RANGE NAVIGATION (VOR)

C-1. COURSE SELECTOR and INDICATORS

The course selector dial is edge-operated and located at the lower part of the panel. It is calibrated every 5 degrees from 0° to 360°.

The LEFT-RIGHT meter is located in the upper left corner of the panel, and the TO-FROM meter is located near the center.

C-2. COURSE *TO* STATION (Homing)

1. Make sure that the FUNCTION SWITCH is set to VOR.
2. Tune to the desired omni-range station on the receiver dial. The identification will be heard in the headset or loudspeaker. Tune for maximum deflection of the TO-FROM meter (either up or down).
3. Rotate the COURSE SELECTOR dial until the LEFT-RIGHT (L-R) meter centers, and the TO-FROM (T-F) meter reads "TO". Two different COURSE SELECTOR settings will be found (which are 180° apart) where the L-R meter centers, but only one of these will cause the T-F meter to read "TO".
4. Turn the airplane until the magnetic compass reads the same as the COURSE SELECTOR dial. The omni indications do not depend upon the attitude or heading of the airplane, but only upon its bearing from the ground station, and so will not change as the airplane is turned to the magnetic heading which corresponds to the bearing to the ground station.
5. When approaching close to the VOR station, the needle may become difficult to hold to center. Notice the compass heading you have been flying in the approach, and fly by compass until far enough beyond the station to make it easy to hold center again. Any off-course error will be indicated, along with the direction for the correction, after the station has been passed.
6. If, for some reason, the airplane gets noticably off-course as indicated by the L-R indicator, the COURSE SELECTOR can be reset to center the L-R meter. This will establish a new track to the station which is a straight line from the off-course point to the station, and is shorter than flying back to the original course.
7. The difference between the course setting as indicated by the COURSE SELECTOR and the magnetic heading of the airplane necessary to keep the needle centered, is the wind correction angle (plus any errors in the compass), which will be found useful in estimating the wind velocity and direction.

C-3. COURSE *FROM* STATION

Any desired course outbound FROM the station may be set on the COURSE SELECTOR and followed by correcting the heading of the airplane to keep the L-R needle centered with the T-F meter reading "FROM".

As the distance from the station increases in flying outbound, the signal will gradually grow weaker as indicated by a decreasing deflection of the T-F meter. When the signal gets so weak as to cause the T-F meter to read in the red sector (with the receiver properly tuned for maximum T-F deflection) it is no longer reliable, and another stronger omni station should be found.

C-4. ORIENTATION

The OMNI-RANGE system can be used for orientation (obtaining a "fix" when airplane's location is in doubt).

Bearings to ground stations do not depend upon the attitude or heading of the airplane, and hence can be taken easily and accurately in rough air. No heading correction is necessary.

To use the omni system for orientation, the following procedure is recommended:

1. Choose two omni stations for bearings, which are as near 90° apart as possible, and which are within 50 miles of your probable location. (Longer distances can be safely used at higher altitudes).
2. Tune in No. 1 omni station and check its identification. Tune for maximum deflection of the T-F meter.
3. Rotate COURSE SELECTOR dial until L-R meter centers and T-F meter reads "FROM".
4. Record bearing, and draw line from omni station on chart in direction of bearing.
5. Tune to No. 2 omni station and repeat steps 2, 3 and 4 above, but for No. 2 station.
6. Location of airplane is at the intersection of the two lines drawn on the chart.
7. Add other bearing lines from other omni stations, as desired, to improve accuracy of "fix".

D. LOCALIZER OPERATION (ILS)

D-1. TONE LOCALIZER

a. Set the FUNCTION SWITCH to VAR.
b. Tune in the tone localizer station. Refer to the AIRMANS GUIDE for frequencies, courses, and other pertinent data.
c. The Left-Right needle will center when on-course, and will point toward the track when approaching on the prescribed inbound tone localizer course, but will deflect in a reverse sense when flying an outbound localizer course, or when making an inbound approach from the BACK DIRECTION (normally used only when extreme wind conditions warrant).

D-2. PHASE LOCALIZER

This is the latest ILS approach system of which only a few installations have been so far made.

a. Set the FUNCTION SWITCH to PH. L.
b. Tune in the phase localizer station. Refer to the AIRMANS GUIDE for frequencies, courses, and other pertinent data.
c. The Left-Right needle will center when on-course, and will point toward the track when approaching on the prescribed inbound phase localizer course, but will deflect in a reverse sense when flying an outbound localizer course, or when making an inbound approach from the BACK DIRECTION (normally used only when extreme wind conditions warrant).

E. VISUAL-AURAL RANGE NAVIGATION (VAR)

1. Set the FUNCTION SWITCH to VAR.
2. Tune in the VAR station. Refer to the aeronautical charts for frequencies and locations of the blue and yellow sectors of the VAR stations.
3. The Left-Right needle will center when on-course, or point to the blue or yellow sector when off-course, with sensing as shown on the charts.
4. The aural tone (A or N) indicates on which side of the station the airplane is located, and is shown on the charts.

F. EXTERNAL LEFT-RIGHT METER

A larger LEFT-RIGHT meter which fits a standard 3 1/8" aircraft instrument hole is available. A 3-pin connector is provided on the rear panel of the set. It can be connected to operate in place of the LEFT-RIGHT meter on the panel of the set, or in addition to it at a somewhat reduced sensitivity.

Section II .. Installation

A. VHF TRANSMITTER-RECEIVER UNIT (VTR-1) (See Fig. 1)

1. Cut a rectangular hole in the instrument panel measuring 6 1/4 inches wide by 4 3/4 inches high.
2. Remove case from set, and install in this cut-out using machine screws and stop-nuts in the holes provided in the flanges. Set is held in by single wing nut at rear.
3. Install a rear support strap between the rear surface of the case, and some nearby structural member. Be sure there is at least 2 inches behind the case to accomodate the various plugs and cables which connect to the rear of the set.
4. Slide the set into its case, and reattach rear wing nut and washer, tightening fully.

B. MODULATOR-POWER UNIT (V12MP-2 see Fig. 2)

1. Fasten the power unit mounting plate to either a vertical or horizontal surface using four No. 10 machine screws and stop nuts.
2. Attach the two power unit mounting brackets to the top, rear, or bottom of the power unit, so as to place power unit upright when mounted.
3. Start the four power unit mounting screws (No. 10A) but leave about 1/8 inch between their heads and the U nuts in the mounting plate.
4. Slip the power unit into place, and push to the proper side to engage the mounting screws in the slots provided for them.
5. Tighten all four mounting screws.

C. OMNI RECEIVING ANTENNA (See Fig. 3)

The full range and accuracy of the VHF omni-range system can only be realized when the airplane is equipped with the proper type of antenna.

A horizontal V-type is absolutely necessary; a vertical whip is definitely not satisfactory, although it may appear to be when tried. Vertically polarized components are not radiated by the ground stations, but are produced by reflections. Therefore a vertical antenna may receive strong signals, but not directly from the ground station, giving rise to very unreliable bearings.

The location of the antenna is likewise of paramount importance. It is advisable to place it on the top of the airplane behind the cockpit and well away from the engine(s) and propeller(s).

Some very successful installations have also been made placing the antenna on the lower surface of the fusilage, and also on the top of the vertical stabilizer. The nose of the V should face directly forward or rearward, and the rods should be horizontal in level-flight attitude.

The antenna mast contains a matching balun which serves as both an impedance transformer and a means to connect a coaxial line to a balanced V antenna. It is made of a special type of transmission cable cut to critical dimensions, and should not be disturbed. If the mast is not used, this balun must be removed from it, and reinstalled between the antenna rods and the cable to the set. Be sure to ground all coax sheaths at the point where the balun connects to the set cable.

D. VHF TRANSMITTING ANTENNA (See Fig. 4)

The VHF transmitting antenna should be mounted on a metal plate measuring at least 18 inches square for best results. Such a mounting surface is often found directly in front of the windshield in fabric-covered ships, and at the center of the cabin roof in metal ships. Where no such surface is available, a piece of thin aluminum may sometimes be affixed flush with the fabric. This thin aluminum sheet or foil may be made to conform to the various curved surfaces to which it is mounted, but all cuts and seams should be along lines radiating from the center point. A 7/16 inch hole should be in the center of this sheet for mounting the antenna. It is recommended that where necessary a metal supporting plate be provided for the antenna to resist the bending load imposed by the slipstream. Do not lengthen or shorten the antenna. It has been cut the proper length for the most efficient radiation at the frequencies generated by this transmitter. Do not attach other wires or devices to it, and locate it at least 12 inches from the nearest projecting object or other wire. The method of attaching the transmission line to the antenna is illustrated in Figure 4 and should be rigidly followed. The length of the transmission line is not critical, but it is polyethylene-insulated and can be shortened only by someone experienced in the special techniques of handling it. Excess transmission line can be neatly coiled at any convenient point provided that at least a six-inch radius is used in coiling. All bends in the transmission line should be smooth and gradual, to prevent possible trouble later on.

E. MARKER BEACON ANTENNA (See Fig. 5)

The marker beacon antenna, which is not furnished with the equipment, should be fabricated from suitable antenna wire. It should be located under the fusilage and spaced about six inches away from it by a pair of suitable support masts. Note that the point where the lead-in is connected is five inches displaced from the center of the antenna wire. This dimension is important for proper matching.

The coaxial feed cable has its sheath connected to the metal skin or frame of the aircraft at a point opposite the connection to the wire. The center conductor is usually connected to a feed-thru insulator, which in turn is connected to the antenna wire.

It is well to locate the marker beacon antenna as far aft as possible, to reduce engine noise pick-up.

It has been found that placing the tap forward or aft of the center can make a large difference in performance due to capacity unbalances, etc. It is therefore suggested that the tap be moved to the other side of center, if poor marker beacon reception is obtained.

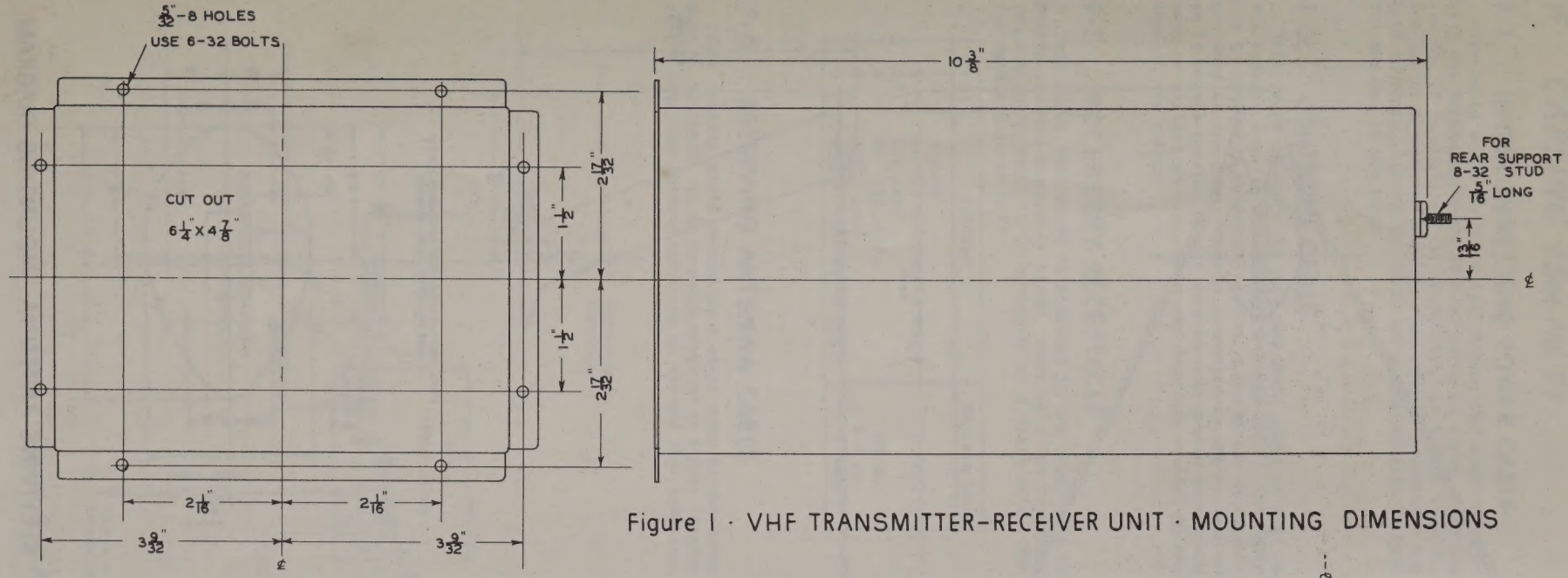


Figure 1 · VHF TRANSMITTER-RECEIVER UNIT · MOUNTING DIMENSIONS

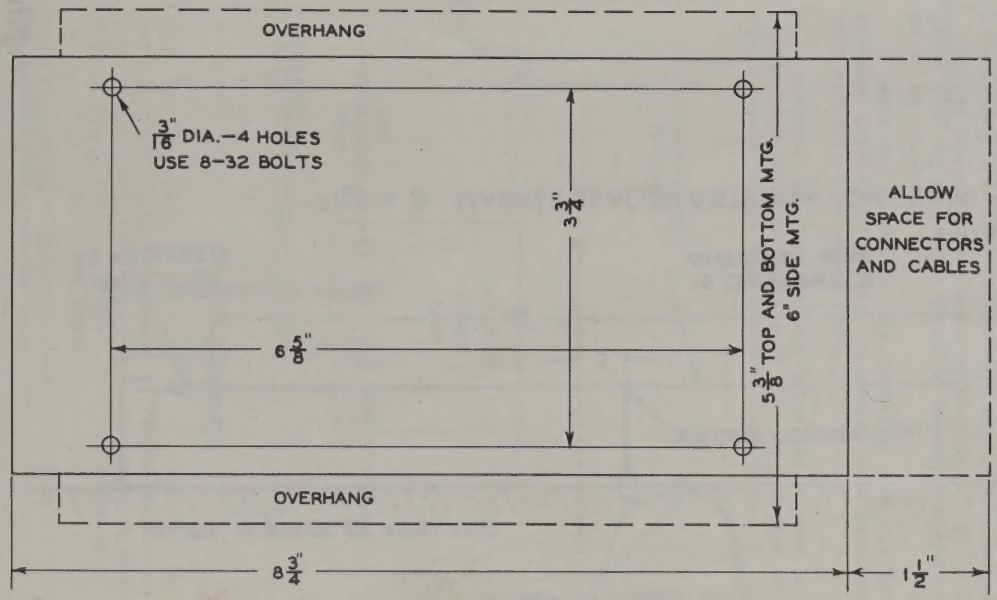


Figure 2 · MODULATOR-POWER UNIT · MOUNTING DIMENSIONS

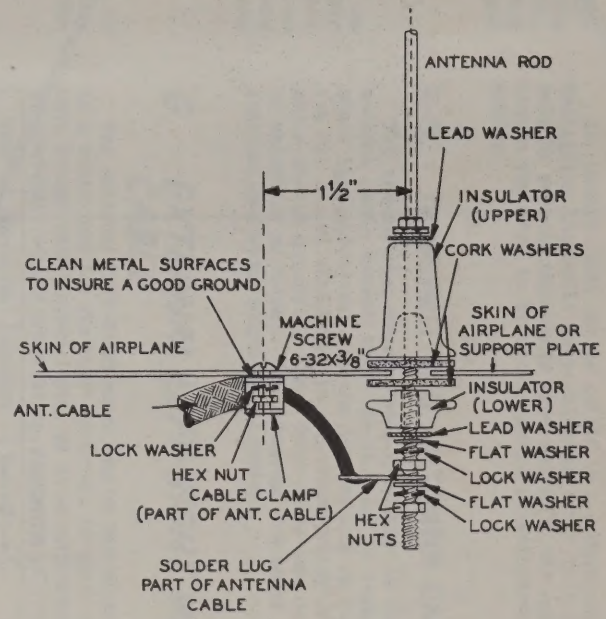


Figure 4 · TRANSMITTING ANTENNA
MOUNTING DIAGRAM

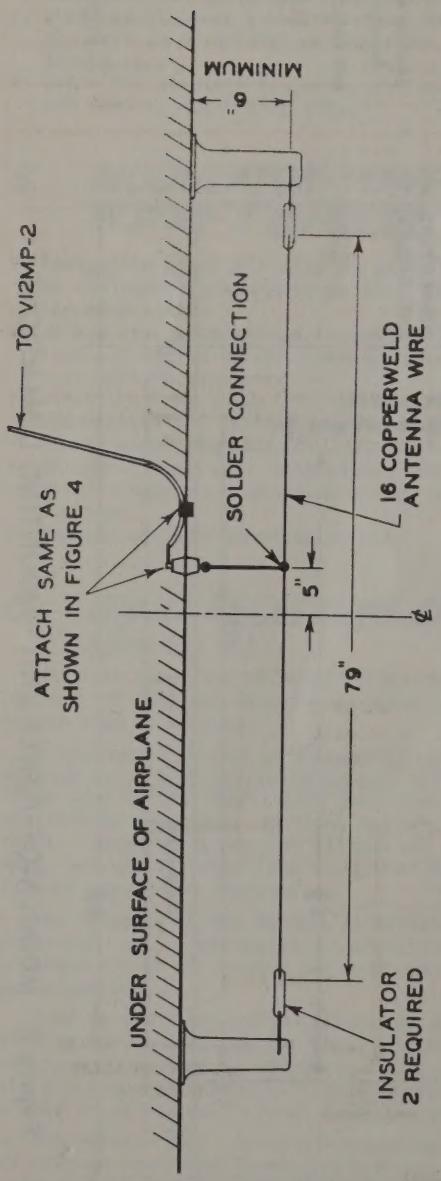


Figure 5 · MARKER BEACON ANTENNA · DIAGRAM

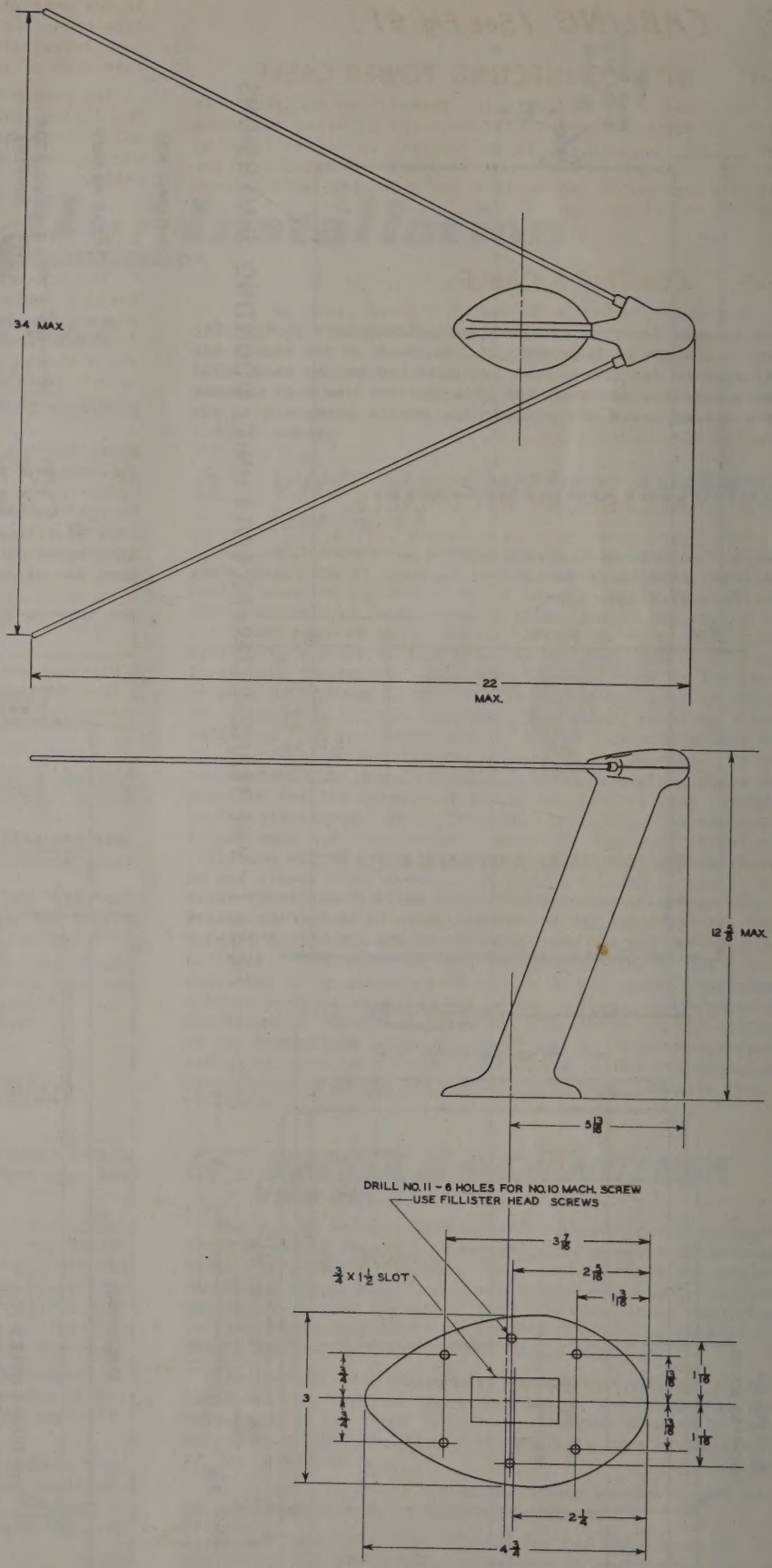


Figure 3 · RECEIVING ANTENNA · MOUNTING DIAGRAM

F. CABLING (See Fig. 6)

F-1. INTERCONNECTING POWER CABLE

The cable which connects the TRANSMITTER-RECEIVER UNIT with the MODULATOR-POWER UNIT contains 11 wires including two No. 16 conductors. It is supplied in 8-foot lengths, and can be lengthened provided that heavier conductors are used to replace the two No. 16's, and a shielded wire is used for the No. 11 pin lead.

F-2. CONTROLS CABLE

This cable connects the mike and phone jacks as well as the speaker lead to the MODULATOR-POWER UNIT. The cable can be lengthened as needed. The No. 6 pin of the receptacle provided on the power unit is connected to the A+ lead so as to permit testing of the sets in test stands previously used on earlier models. This pin does not connect to any lead in the cable.

F-3. ACCESSORY RECEPTACLE

This extra receptacle is provided in the power unit to enable various accessory items such as a low-frequency receiver attachment to be connected at a later date. The voltages available are:

Pin	Voltage	Maximum Load
1	Ground	-
2	A+ (12-volt units only)	1 amp.
3	Not used	-
4	B+ 150 volts	30 ma.
5	Audio Lead	0.5 ma.
6	A+ (24-volt units only)	1 amp.

F-4. RECEIVING ANTENNA CABLE

This coaxial cable should be a small size 52-ohm cable such as RG-58A/U. It is normally supplied in 8-foot lengths with a long type antenna connector on one end (for insertion in the rear of the transmitter-receiver unit) and a short type connector on the other end for insertion in the antenna base receptacle. A longer cable can be used, but splicing this type of cable is not recommended.

Any excess cable can be coiled in a convenient location. Shortening the cable is permissable, but this can be done only by persons thoroughly experienced in the special techniques required to properly handle polyethylene-insulated cables.

F-5. TRANSMITTING ANTENNA CABLE

The transmitting antenna cable is similar to the receiving antenna cable except that the set end is terminated in a short type connector, and the antenna end is fitted with a lug for direct attachment to the transmitting antenna base, and a sheath grounding lug. This cable can be lengthened or shortened as needed. See paragraph F-4 above for special instructions about polyethylene cables.

G. EXTERNAL LEFT-RIGHT METER CABLE

The external LEFT-RIGHT meter can be connected to operate as a substitute for the built-in meter, in which case it will have normal course sensitivity, or as an additional indicator at somewhat reduced sensitivity. Connect as follows:

Type of Operation	Connect + to	Connect - to	Jumper
External Meter only	pin 2	pin 1	-
Both Meters	pin 2	pin 3	-
Internal Meter only	-	-	pin 2 to pin 3

A plug containing a jumper between pins 2 and 3 is supplied with the set, which should be removed when the external meter is connected.

A cable and connector are supplied with the Model M-2 EXTERNAL LEFT-RIGHT METER. It mounts in a standard 3 1/8 inch aircraft instrument hole.

A standard ILS cross pointer meter can be used as an external LEFT-RIGHT meter, but it will be sluggish in operation because of its high internal resistance.

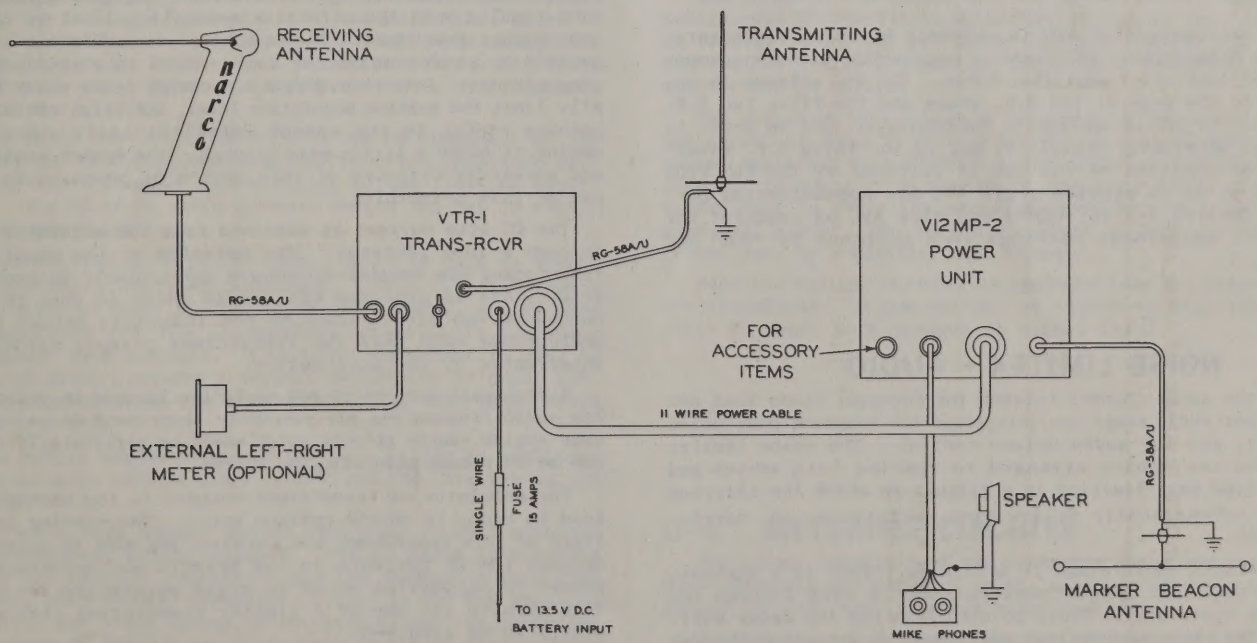


Figure 6 · CABLING DIAGRAM

Section III .. Circuit Description

A. VHF RECEIVER (See Fig. 7)

A-1. PRE-SELECTOR

The VHF pre-selector section includes a tuned R.F. amplifier stage with three resonant circuits between the antenna line and the converter tube grid, which provides a high rejection of unwanted image and other spurious interferences. Two of these resonant circuits form a capacitively-coupled double-tuned coupling network between the R.F. amplifier plate, and the converter grid. The coupling is set somewhat below critical.

A separate local oscillator is used and injected into the converter grid circuit. Temperature compensation is used to stabilize the oscillator frequency.

The tuning system is a four-gang permeability mechanism with a reduction gear drive. Positive stops are provided at each end of the range, arranged to prevent damage to the gears thru excessive pressure at the ends of the tuning range. The trimmer capacitors are mounted on the coil assembly, which is mounted on the chassis in such a manner as to reduce drift resulting from chassis strains, etc.

A-2. I.F. AMPLIFIER - DET - AVC

Three stages of I.F. amplification are used employing eight resonant circuits to secure high sensitivity and selectivity. The coupling within the I.F. transformers has been chosen to provide a broad blunt nose for ease of tuning, along with steep sides for separation of adjacent channel stations. The I.F. amplifier is peaked at 10.7 megacycles. A high-level diode detector is used to insure adequate linearity for use with the VHF omni-range system. The omni-range output signal is taken directly from the detector diode load.

An extremely flat AVC is obtained by using a separate, highly delay-biased AVC diode in conjunction with the proper type of controlled amplifier tubes. The AVC voltage is applied to the grid of the R.F. stage and the first two I.F. stages. No AVC is applied to the converter tube in order to improve oscillator stability, nor to the third I.F. stage. The time constant of the AVC is switched by the FUNCTION SWITCH so as to provide rapid AVC for communication purposes (switch set to "COM") and slow AVC as required for accurate omni-range bearings when switched to "VOR" and "PH. L."

A-3. NOISE LIMITER - AUDIO

In the aural channel between the detector diode load and the first audio stage are interposed the compound peak noise limiter, and the audio volume control. The noise limiter includes two diodes arranged to combine both series and shunt-type peak limiting in a circuit in which the clipping levels automatically follow slow variations in carrier strength.

The first audio stage is a high-mu triode in a cathode-biased circuit. Additional current is bled through the cathode resistors in order to stabilize the AVC delay voltage. The plate of the first audio stage is connected through the power cable to its load resistor, which is located in the power unit, along with the second audio stage and its associated components.

The modulator tube is used also as the receiver audio power output tube. The plate lead from the first audio stage is coupled to the modulator grid through a combining network. The circuits are arranged so as to remove the screen voltage from the speech amplifier except when transmitting, and when the marker beacon receiver is on.

The modulation transformer also contains output windings designed to match a 150 to 600-ohm headset load, or a 3-ohm speaker voice coil. Simultaneous operation of speaker and headset is possible, but at somewhat reduced output. Relay contacts are arranged to remove the transmitter load when receiving, and to remove the loudspeaker and reduce the headset load when transmitting.

B. MARKER BEACON RECEIVER (See Fig. 8)

The marker beacon receiver circuits are located in the power unit. It comprises a tuned R.F. stage and detector-audio amplifier. The resonant circuits are peaked at 75 megacycles providing a considerable audio output for a 2.5 millivolt marker type signal (modulated 100% at 3000 cycles). Plate power to the R.F. stage is controlled by a push-pull switch located on the panel of the set.

C. VHF TRANSMITTER (See Fig. 7)

The VHF transmitter employs three tubes. V-301 is used as a third overtone crystal oscillator on 30.5 mc. Eight crystal sockets are provided which are selected by means of a rotary switch. V-302 is a double-amplifier which drives the final output double-amplifier, V-303. The antenna is inductively coupled to the final tank circuit.

The speech amplifier and modulator circuits differ somewhat from convention, and so will be described. Recent studies have indicated that considerably improved communication results when the effective modulation level is raised much higher than usual. The resulting overmodulation can be avoided by predistorting the audio signal in a speech-clipping circuit. This removes the low-energy peaks which normally limit the maximum modulation level, but which contribute nothing useful to the speech intelligibility other than making it sound a little more natural. The speech amplifier and modulator circuits of this series of power units make use of this principle.

The DC mike current is obtained from the modulator bias through a load resistor. The omission of the usual mike transformer has several advantages particularly in reducing weight, and in avoiding the damage which is done to many carbon button microphones by the inductive "kick" which would occur each time the transformer primary circuit is interrupted by the mike switch.

A high-gain pentode speech amplifier is used in which the low audio frequencies are purposely suppressed so as to reduce engine rumble effects which would be particularly bothersome in a high-gain clipping system.

The modulator is transformer-coupled to the transmitter load in order to obtain optimum match. The winding polarities of this transformer are important and must be preserved because the DC currents in the primary and secondary are phased in opposition so as to avoid saturating the core. This permits the use of a lighter transformer than would otherwise be required.

Side-tone signal is supplied to the headsets by inserting a dropping resistor in series with the phone jack and its transformer winding, in the "TRANSMIT" operation.

D. OMNI-RANGE SECTION
(See Fig. 7)

D-1. OMNI SIGNAL DESCRIPTION

No attempt will be made here to describe in detail the technology of the VHF omni-range system. Briefly, the ground station sends out one continuous VHF carrier wave with three simultaneous, but non-interfering amplitude modulations. These are:

1. Voice modulation. 200 to 2500 cycles. (35% max. mod.).
2. Reference phase signal. (30% mod.). 9960 cycles subcarrier frequency -- modulated between 9480 and 10440 cycles at a fixed phase.
3. 30 cycles (30% mod.) produced by effectively rotating a limacon antenna pattern 30 times per second at the station.

The variable phase signal is thus a 30-cycle sine wave modulation whose phase angle relative to the 30-cycle FM on the 9960-cycle subcarrier depends upon the bearing of the airplane's receiving antenna to the station. The station is adjusted so that the variable phase signal is "in phase" with the reference phase at a bearing due magnetic north (0° mag.) from the station.

Thus the audio signal developed across the detector load resistor in the receiver contains the above three separate and distinct audio components which are mixed together in simple addition. It is the purpose of the omni circuits to separate these components, and to indicate by means of a course selector dial, and some indicating meters, the relative phase angle between the variable phase signal and the reference phase signal, as received, and to thus indicate the bearing to the station.

D-2. REFERENCE PHASE CHANNEL

The 9960-cycle subcarrier component of the audio signal, which is frequency-modulated at a 30-cycle rate is passed through a two-section RC type high-pass filter to the grid of the limiting amplifier tube (V-208). This filter prevents the 30-cycle variable phase and voice components from passing into the reference channel amplifier.

The limiting amplifier tube is operated at reduced plate and screen voltages, and with no fixed grid bias, so as to saturate readily and thereby remove any amplitude modulation of the 9960-cycle subcarrier (propeller modulation, etc.). It drives a ratio detector (V-207) through a discriminator transformer (T-202).

The ratio detector demodulates the FM component of the signal, but is relatively unresponsive to any amplitude modulation which remains in the output of the limiting amplifier. The 30-cycle ratio detector output voltage is developed across R-255.

A pi-section RC-type low-pass filter is used to remove the residual subcarrier component. This filter causes a phase shift of about 25° in the 30-cycle signal, and is used to compensate for the accumulated phase shift variation throughout both channels. A variable resistance (R-248) is included which provides a vernier adjustment of about ±2°. Larger compensations are made by selecting the fixed series resistor R-247.

The output signal from the low-pass filter is amplified in a high-gain pentode stage (V-206) and fed into the output stage (V-205).

The reference channel output amplifier (V-205) provides two independent output signals. One of these is obtained across the cathode resistance and fed through a very high capacity electrolytic capacitor (C-216) to the L-R metering circuit. The other output is obtained across the capacitor plate load (C-218) which shifts the phase of this voltage by 90° with respect to the grid voltage. This shifted phase signal is used to drive the TO-FROM metering circuit through an electrolytic capacitor (C-217).

D-3. VARIABLE PHASE CHANNEL

The 30-cycle variable phase component of the audio signal is fed through an RC-type parallel-T band-rejection filter tuned to 60 cycles, and thence through an RC-type band-pass filter tuned to 30 cycles, to the grid of the first voltage amplifier stage (V-201A). The purpose of the 60-cycle rejection filter is to prevent 60-cycle components which are generated by propeller modulation at certain critical engine speeds (usually 1800 RPM) from causing errors in the readings and slow oscillations of the meter needles. The 30-cycle band-pass filter removes voice frequency and 9960 subcarrier components along with very low frequency fluctuations, arising in the VHF propagation, which would cause the meters to fluctuate erratically.

The output of the first voltage amplifier stage (V-201A) is fed to the input of the phase-splitter stage (V-202A) through another 30-cycle band-pass filter to further remove the undesired components. This tube has both plate and cathode resistors, which are equal in value, and thereby generates two output voltages equal in amplitude but 180° apart in phase (phase inverter).

Coupled to these two outputs is an RC-type phase-dividing bridge (C-210, C-211, R-217, R-218) in which the resistors and capacitors have been selected to produce four equal voltages (to ground) at each of the four bridge corners, but spaced at exact 90° phase intervals. For this condition to obtain, the capacitive reactances must exactly equal the resistances (at 30 cycles). The component parts of this bridge are therefore very critical, and are held to very close tolerances.

The four output voltages from the corners of the bridge are fed into four cathode follower sections (V-203 and V-204) which serve as impedance transformers to drive the relatively low impedance phase shifter (course selector).

The course selector is a continuously-variable phase shifter which produces a 30-cycle output which can be set to any desired phase relative to the input signal. The phase angle between the output voltage (movable arm to ground) and the zero phase input voltage is indicated directly on the hand-calibrated course selector dial.

The tapped potentiometer course selector is essentially uniform in resistance (linear taper) having a total loop resistance of about 10,000 ohms with taps at 2500, 5000 and 7500 ohms.

The output of the course selector potentiometer feeds into a high-pass RC-type filter which further reduces low-frequency fluctuations, and partially compensates for the phase shift at 30 cycles produced by the 60-cycle parallel-T network described earlier.

The output of this filter is the input to the second voltage amplifier stage (V-201B) which drives the variable phase output amplifier tube (V-202B). The output of V-202B is fed into the primary of a specially designed audio stepdown transformer to drive the metering circuits with a balanced push-pull signal. The DC plate current is kept out of this transformer by a parallel feed circuit.

Negative voltage feedback is employed from the primary of the transformer to the cathode of V-201B to stabilize the shift in phase with changes in signal level.

D-4. METERING CIRCUITS

The output signals from the reference phase and variable phase channels are combined in the metering circuits to indicate certain relative phase relationships.

The metering circuits are in effect AC wattmeter circuits.

For small deviations from 90° and 270° phase angles the meter deflection will be approximately proportional to the amplitude and direction of the deviation angle.

Both the L-R meter and TO-FROM meter use similar circuits, but the T-F metering circuit is driven from the capacitor loaded plate circuit of the reference phase output amplifier stage (V-205)•in which the phase of the plate circuit output voltage is shifted about 90° from the grid excitation voltage. This causes the T-F meter to deflect to its maximum degree when the L-R meter is centered (zero deflection), and in a direction (up or down) which depends on whether the two phase channels are 90° or 270° apart in relative phase.

A very large electrolytic capacitor (C-215) is connected across the L-R meter to add to the meter damping, and help to smooth out rapid fluctuations which arise from many sources.

E. TONE LOCALIZER (VAR) (See Fig. 7)

The audio output from the receiver is also connected to the input of V-109. When a VAR or TONE LOCALIZER station is being received, the audio signal comprises a mixture of 90 and 150-cycle components, plus voice. These signals are amplified by V-109 and fed into two resonant circuits tuned to 90 and 150 cycles. The two audio tones are thereby separated. They are rectified by the crystals XT-101 and XT-102, and the DC currents mixed and fed through the Left-Right meter when the FUNCTION SWITCH is set to "VAR". A balancing potentiometer (R-132) is provided to compensate for variations in filter response and crystal efficiency, and is set so as to cause the meter to read zero when equal amounts of 90 and 150-cycle components are fed into it.

F. PHASE LOCALIZER (See Fig. 7)

In the "PH. L." position of the FUNCTION SWITCH the circuits are connected as for omni-range operation, except that the course selector is bypassed in such a way as to be equivalent to setting it to 90°. A reduction in the signal amplitude is also made by the voltage divider comprising R-223 and R-224. The phase localizer signal includes a reference phase signal identical to the omni-range signal, but the omni variable phase (constant amplitude) signal is replaced by a 30-cycle reversable phase variable amplitude signal which has zero amplitude on-course, and a rising amplitude off-course in phase with the reference phase signal on one side, and 180° reversed in phase on the other. The 90° point on the phase bridge is used to get maximum metering circuit sensitivity.

G. POWER SUPPLY (See Fig. 8)

The vibrator system is of the non-synchronous interrupter type. Every precaution has been taken in the design to provide the utmost in dependability and long life.

The primary input circuit includes a hash filter primarily to prevent interference in cases where the VHF equipment is used in conjunction with a low-frequency receiver, and a high-capacity electrolytic capacitor to aid in supplying the peak currents required by the vibrator system.

The vibrator was specifically designed for this equipment, so it is absolutely necessary that any replacement be identical to the original. No substitute can be expected to provide the same performance or life. The vibrator transformer is somewhat larger than is customary in aircraft radio equipment to provide better reliability. Again, any replacement must be made with the identical part.

The buffer or timing capacitor is divided between the primary and secondary of the transformer. This placement of a substantial part of the timing capacitance across the primary winding is very beneficial to a 12-volt vibrator system. It prevents the usual starting difficulties, and short vibrator life, that have characterized such vibrator systems in the past.

Replacements for either timing capacitor should be identical to the originals, and preferably obtained from the factory.

The rectifier system comprises four selenium stacks arranged as a full wave voltage doubler. Thus a 280-volt output is obtained for the modulator and transmitter operation, and a 140-volt output for the receiver and omni-range circuits.

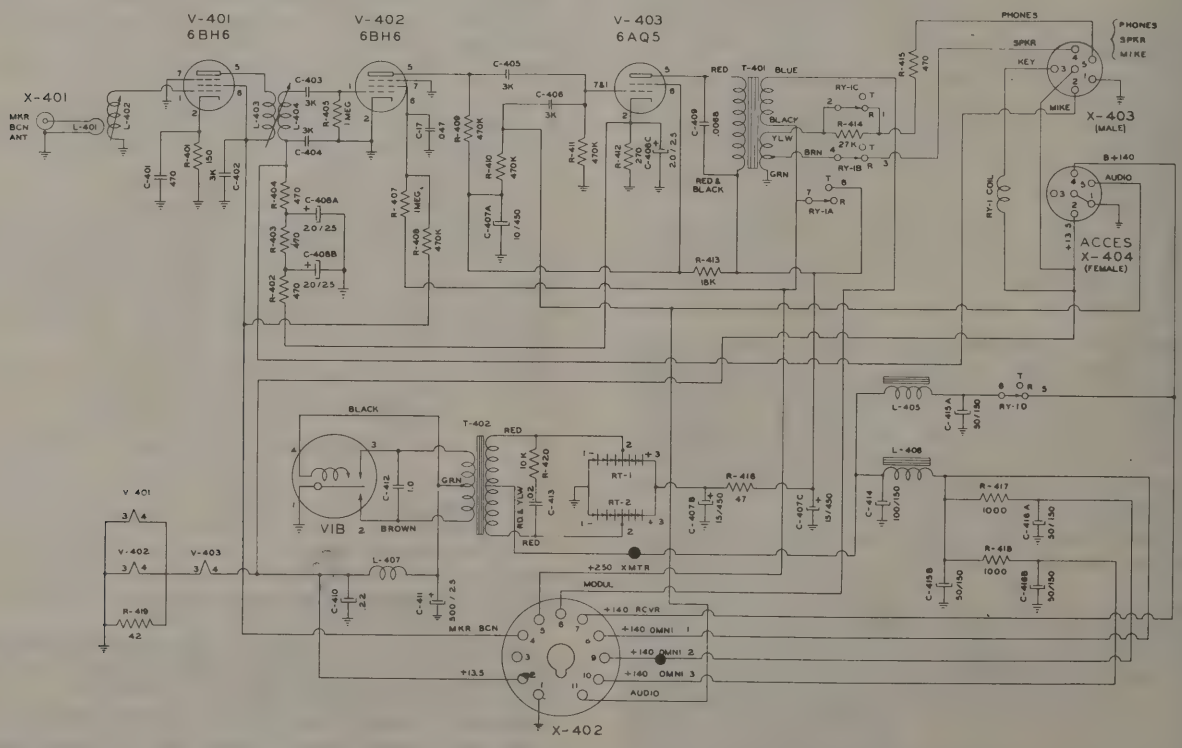


Figure 8 · MODULATOR-POWER UNIT · SCHEMATIC DIAGRAM

Section IV · · Maintenance

A. OPENING SET

Access to the inner parts of the transmitter-receiver unit is accomplished as follows:

1. Remove the four screws marked "A", which hold the sub-chassis to the main chassis. See Figure 13.
2. Loosen the screw marked "B", so as to permit the rear of the sub-chassis to be lifted away from the main chassis.
3. Lay sub-chassis assembly to one side as shown in Figure 14.

Reverse the above process when reassembling set. Be sure wiring cables are tucked in so as to clear the case. Retighten the screw marked "B".

B. ALIGNMENT PROCEDURE

B-1. VHF RECEIVER

1. Open set as described in A above.
2. Connect a signal generator to points C and D (see Figure 14). Keep leads very short to prevent oscillation.
3. Connect audio output meter to PHONES output jack.
4. Set signal generator to 10.7 megacycles and reduce output until audio meter reads conveniently with volume control fully advanced.
5. Peak the tuning screws on the three rear I.F. transformers using an insulated tool. Do not peak the front I.F. transformer at this time. See Figures 12 and 14.
6. Remove the I.F. signal generator, and connect an R.F. signal generator set to 118 mc. to the receiving antenna receptacle. See Figure 11.
7. Tune in the signal, and peak the front I.F. transformer, and the three rear R.F. trimmers. See Figure 14.
8. Reset the oscillator trimmer (front trimmer of group on side of set) only if dial is badly in error, and signal of known frequency accuracy is available.

B-2. MARKER BEACON RECEIVER

The marker beacon receiver is located in the modulator-power unit.

1. Connect a signal generator set to 75.0 megacycles to the marker beacon antenna receptacle. See Figure 17.
2. Connect an audio output meter to the PHONES output jack.
3. Pull the marker beacon switch on the front panel of the transmitter-receiver unit to its ON position.
4. Peak the two marker beacon tuning screws. See Figure 15. A strong R.F. signal is normally required for marker beacon receivers.

B-3. VHF TRANSMITTER

It is not recommended that the VHF transmitter be realigned unless one or more tubes have been replaced, or unless there is a definite reason to believe that it is needed. All alignment should be made with the selector switch set to T-122.5. See Figure 12 for adjusting screw locations.

For cases where the alignment is only slightly off and some output can be detected by placing a Field Strength Indicator (NARCO type T-1) close to the VHF antenna, it is merely necessary to tune all three adjusting screws for the maximum output on the Field Strength Indicator. The panel output indicating lamp can be used to peak the adjusting screws in the absence of a suitable Field Strength Indicator, but is a less precise tuning indicator. CAUTION: IT IS POSSIBLE TO BURN OUT THE OUTPUT INDICATOR LAMP BY OPERATING THE TRANSMITTER WITH THE ANTENNA CABLE NOT PLUGGED IN.

For cases where the alignment is so far off as to yield no response from the Field Indicator meter, it must be adjusted stage by stage. Use a test indicator consisting of a sensitive voltmeter (1000 ohms per volt, or better) with a series 100,000-ohm isolating resistor at the end of a negative probe lead. Ground the positive lead to the metal chassis. The isolating resistor must be located at the end of the voltmeter lead so as to load the circuits under test with a minimum of capacity. Prodeed as follows:

1. Connect the probe lead to pin 9 of V-302 (doubler tube grid). Tune the front adjusting screw for maximum meter deflection.
2. Connect the probe lead to pin 9 of V-303 (output tube grid). Tune the center adjusting screw for maximum meter deflection.
3. Connect the antenna to the transmitter and tune the rear adjusting screw for maximum output as shown by a Field Strength meter placed in the vicinity of the antenna.
4. Retouch all three adjustments for maximum output.

B-4. OMNI-RANGE SECTION

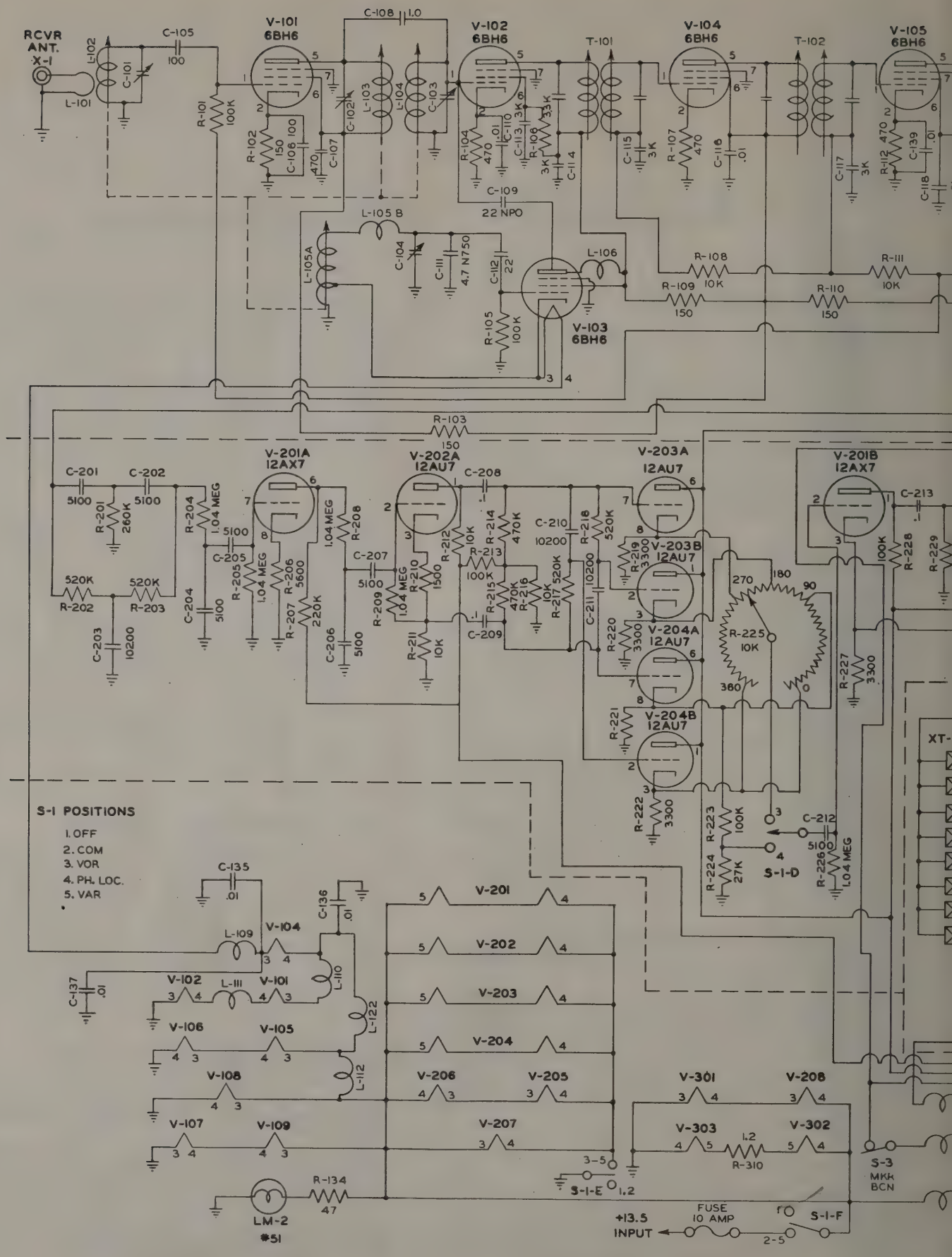
The only tuning adjustments in the omni-range section are the two iron cores which tune the ratio detector transformer coils. These are best aligned with the aid of an oscilloscope, and a real or simulated omni signal fed into the converter. The oscilloscope should be connected to point E (Figure 13) and set to sweep at a 15-cycle rate. The normal signal amplitude at this point is only 0.1 volt, so an oscilloscope with a vertical amplifier will be required. Adjust first the bottom tuning screw (L-202, Figure 14) for maximum undistorted signal as seen on the oscilloscope, and then the top tuning screw for maximum undistorted signal.

B-5. TONE LOCALIZER (VAR)

The balance adjustment, R-132, is set at the factory, and should not be readjusted unless the proper test equipment is available, and there is reason to believe readjustment is needed.

Connect the receiver antenna receptacle to the LOW output jack of a NARCO T-3 Omni-Simulator, or similar instrument. Set up the test set for a "center course" on tone localizer. Tune in the signal, and set the FUNCTION SWITCH to "VAR".

Set the balance control, R-132, (see Figure 13) to center the LEFT-RIGHT meter. Check VAR operation by setting blue and yellow courses.


RCVR ANT. X-1
L-101
L-102
C-101
C-105 100
R-101 100K
V-101 6BH6
R-102 150
C-106 100
C-107 470
C-102 K
L-103
L-104
C-103
C-108 1.0
V-102 6BH6
R-104 470
C-110 .01
C-113 3K
R-109 3K
C-114
T-101
C-115 3K
V-104 6BH6
R-107 470
C-116 .01
T-102
C-117 3K
V-105 6BH6
R-112 470
C-139 .01
C-118
C-109 22 NPO
L-105 B
L-105A
C-104
C-111 4.7 N750
C-112 22
L-106
V-103 6BH6
R-105 100K
R-108 10K
R-109 150
R-110 150
R-111 10K
R-103 150
C-201 5100
C-202 5100
R-201 260K
R-204 1.04 MEG
C-205 5100
R-205 1.04 MEG
R-206 5600
R-207 220K
C-204 5100
C-203 10200
520K R-202
520K R-203
V-201A 12AX7
R-208 1.04 MEG
C-206 5100
C-207 5100
R-209 1.04 MEG
R-210 1500
R-211 10K
V-202A 12AU7
C-208
R-212 10K
R-213 100K
R-214 470K
R-215 470K
R-216 10K
C-209
R-217 520K
C-210 10200
C-211 10200
R-218 520K
V-203A 12AU7
R-219 3300
V-203B 12AU7
R-220 3300
V-204A 12AU7
R-221
V-204B 12AU7
R-222 3300
R-223 100K
C-212 510
R-224 27K
R-226 1.04 MEG
S-1-D
R-225 10K
270
180
90
360
R-227 3300
V-201B 12AX7
C-213
R-228 100K
R-229
XT-
S-1 POSITIONS
1. OFF
2. COM
3. VOR
4. PH. LOC.
5. VAR
C-135 .01
C-136 .01
L-109
V-104
C-137 .01
V-102
L-111
V-101
L-110
L-122
V-106
V-105
L-112
V-108
V-107
V-109
V-201
V-202
V-203
V-204
V-206
V-205
V-207
V-301
V-208
V-303
V-302
1.2
R-310
S-3 MKR BCN
3-5
S-1-E
1.2
R-134 47
LM-2 #51
+13.5 INPUT
FUSE 10 AMP
S-1-F
2-5

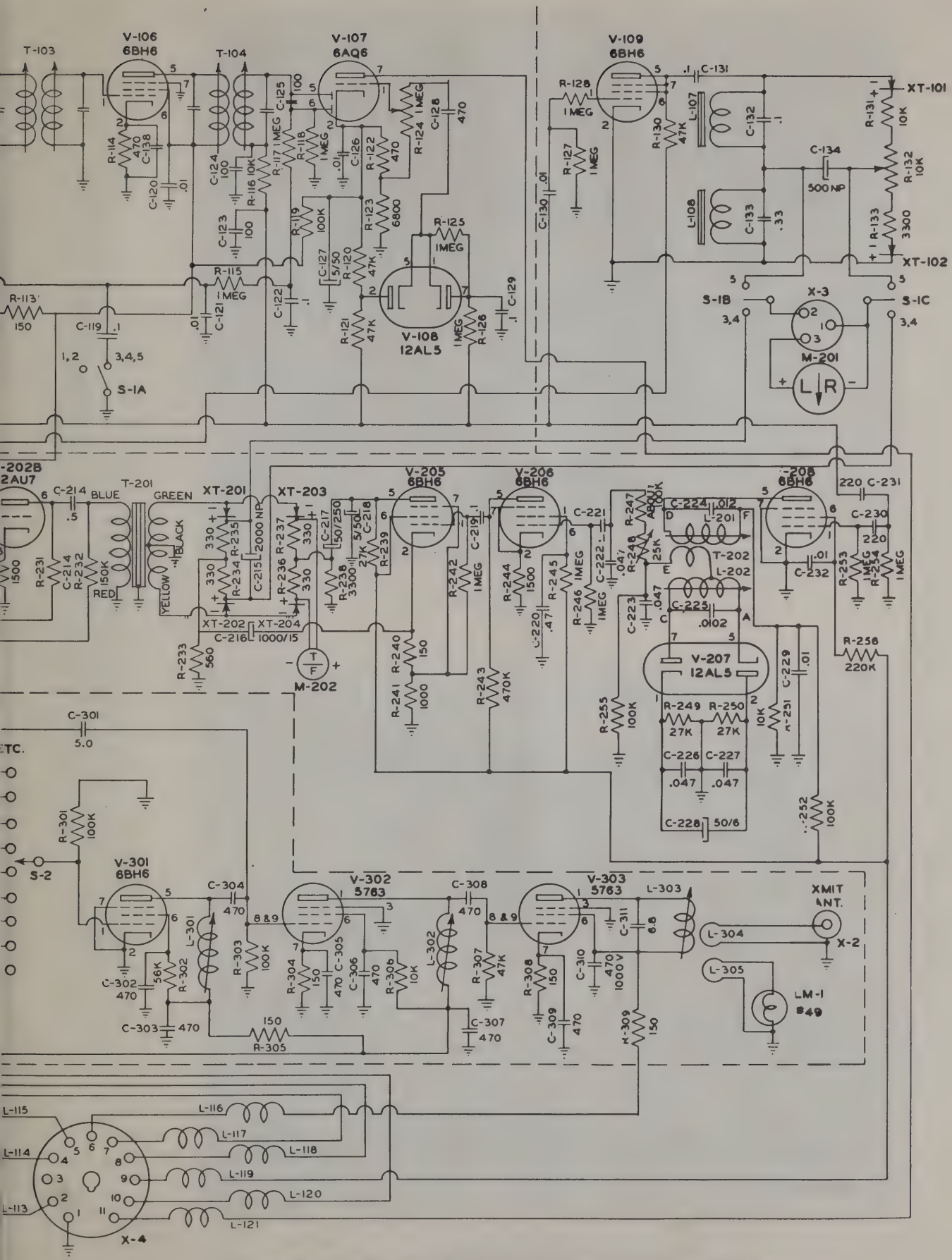


Figure 7 · TRANSMITTER-RECEIVER UNIT · SCHEMATIC DIAGRAM

Figure 10 · FRONT VIEW

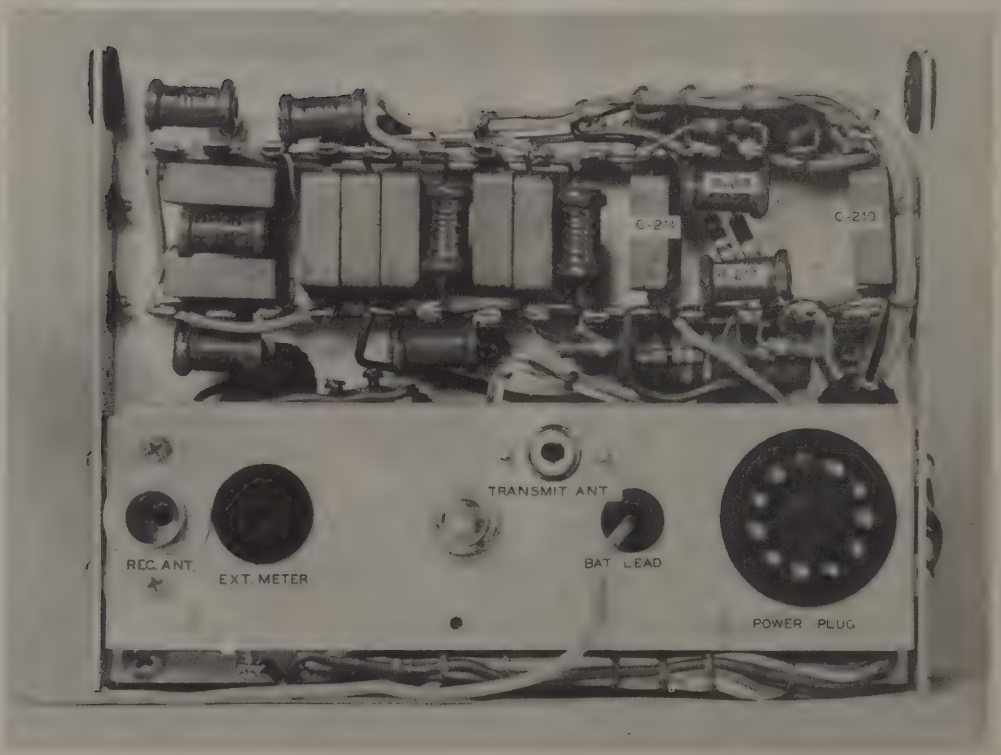


Figure 11 · REAR VIEW

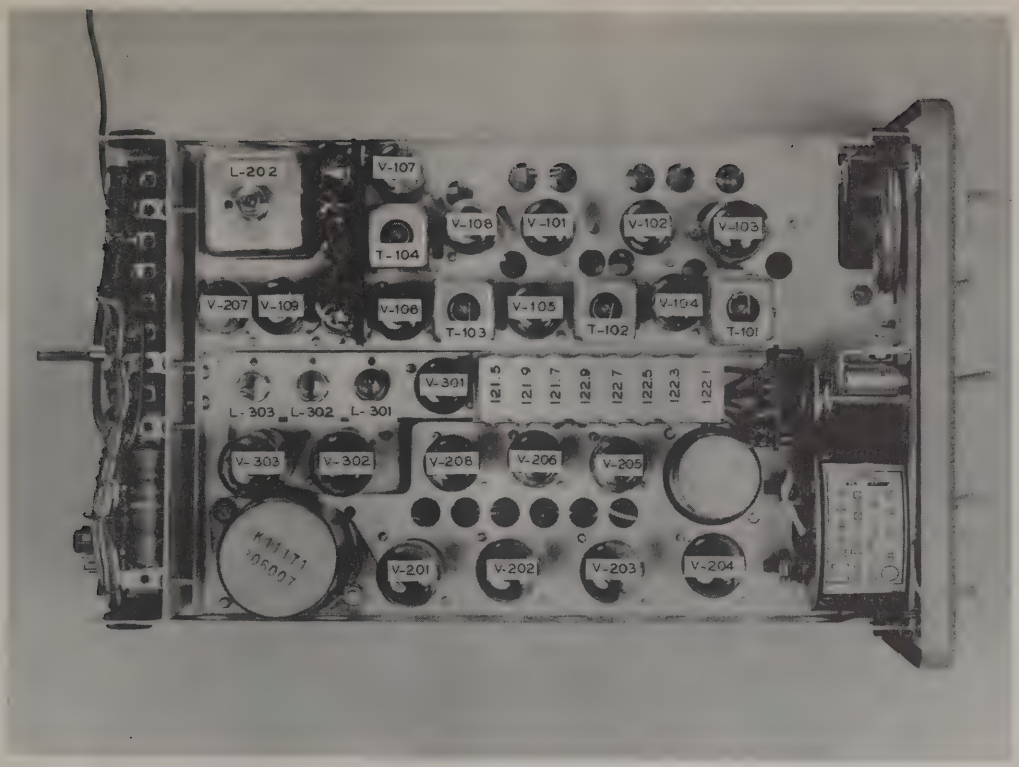


Figure 12 · TOP VIEW

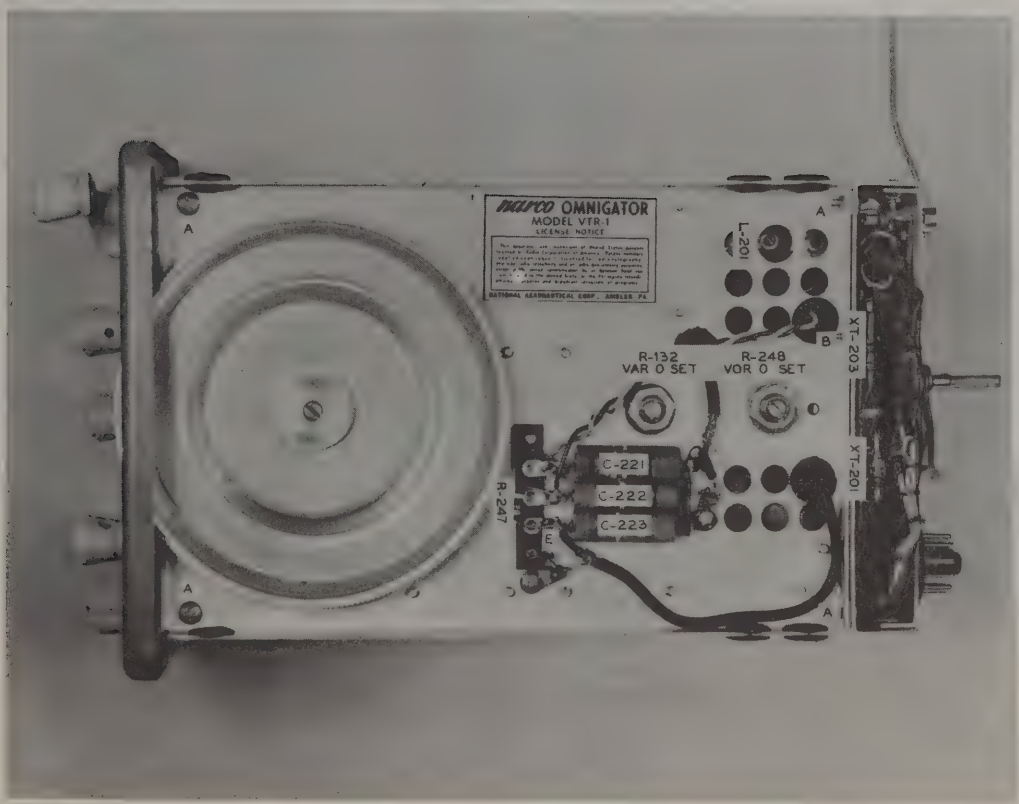


Figure 13 · BOTTOM VIEW

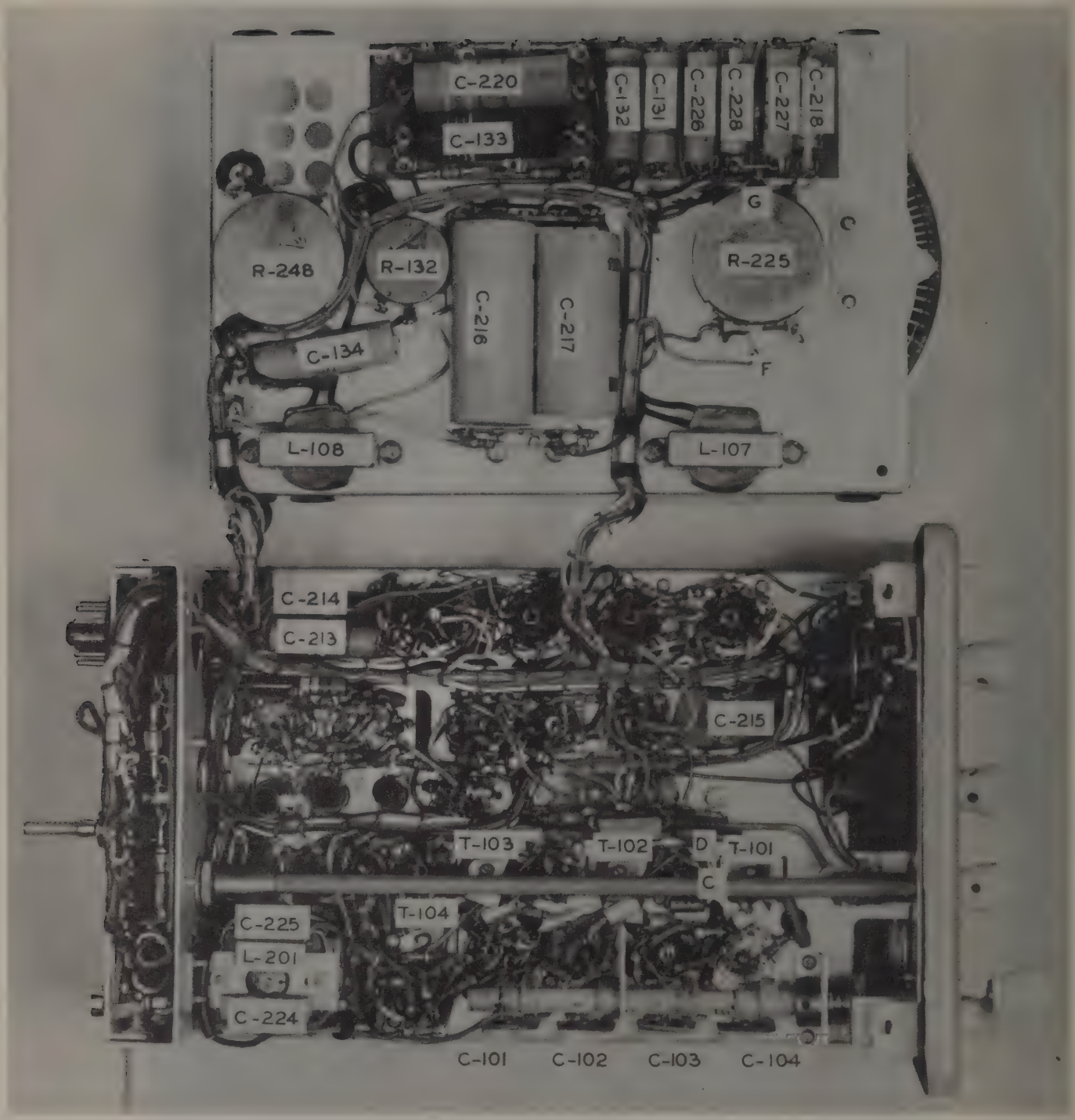


Figure 14 · OPENED VIEW

C. VOLTAGE, RESISTANCE and PHASE ANGLE CHARTS

C-1. VHF RECEIVER

TUBE	PIN	DC VOLTS ①	OHMS ②
V-101	1	--	2 meg.
	2	1.4	150
6BH6	3	+ 6.7	--
	4	+ 13.4	--
RF	5	+140	450 ③
	6	+140	450 ③
	7	0	0
V-102	1	0	0
	2	+ 2.5	470
6BH6	3	0	0
	4	+ 6.7	--
CONV	5	+140	450 ③
	6	+138	3750 ③
	7	0	0
V-103	1	--	100K
	2	0	0
6BH6	3	0	0
	4	+ 6.7	--
OSC	5	+140	450 ③
	6	+140	450 ③
	7	0	0
V-104	1	--	2 meg.
	2	+ 2.1	470
6BH6	3	+ 6.7	--
	4	+ 13.4	--
1st I.F.	5	+140	300 ③
	6	+140	300 ③
	7	0	0
V-105	1	--	2 meg.
	2	+ 2.1	470
6BH6	3	+ 13.4	--
	4	+ 6.7	--
2nd I.F.	5	+140	150 ③
	6	+140	150 ③
	7	0	0
V-106	1	0	0
	2	+ 2.2	470
6BH6	3	+ 6.7	--
	4	0	0
3rd I.F.	5	+140	0 ③
	6	+140	0 ③
	7	0	0
V-107	1	+ 12 ④	6800 ④
	2	+ 13	7270
6AQ6	3	0	0
	4	+ 6.7	--
DET-AUDIO	5	--	110000
	6	--	1 meg.
	7	+ 70	0 ⑤
V-108	1	--	2 meg.
	2	--	55K
12AL5	3	+ 13.4	--
	4	0	0
N/L	5	--	2 meg.
	6	--	--
	7	--	1 meg.
V-109	1	--	2 meg.
	2	0	0
6BH6	3	+ 13.4	--
	4	+ 6.7	--
VAR AMP	5	+ 40	47K ⑪
	6	+ 40	47K ⑪
	7	+ 40	47K ⑪

C-2. VHF TRANSMITTER

TUBE	PIN	DC VOLTS ①	OHMS ②
V-301	1	--	100K
	2	0	0
6BH6	3	0	0
	4	+ 6.7	--
OSC	5	+270 ⑥	150 ⑦
	6	+180 ⑥	56K ⑦
	7	0	0
V-302	1	+270 ⑥	0 ⑦
	2	--	-
5763	3	0	0
	4	+ 13.7	--
DOUBLER	5	+ 7.3	--
	6	+235 ⑥	10K
	7	5.7 ⑥	150
	8	--	100K
	9	--	100K
V-303	1	+250 ⑥	150 ⑧
	2	--	--
5763	3	0	0
	4	0	0
OUTPUT	5	+ 6.4	--
	6	+250 ⑥	150 ⑧
	7	+ 6.7 ⑥	150
	8	--	47K
	9	--	47K

① Measured with high-impedance voltmeter at 13.5 volts input to set.
② Measured to ground, all cables disconnected, except as noted.
③ Measured to pin 7 of X-4.
④ Volume control set at minimum volume.
⑤ Measured to pin 11 of X-4.
⑥ Key down condition.
⑦ Measured to pin 5 of X-4.
⑧ Measured to pin 6 of X-4.
⑪ Measured to pin 8 of X-4.

C-3. OMNI-RANGE SECTION

TUBE	PIN	DC VOLTS ①	OHMS ②	AC VOLTS ⑨	PHASE ANGLE ⑩
V-201	1	+105	100K ⑪	2.8	321°
	2	--	1 meg.	0.4	134°
12AX7	3	+ 1.1	3300	0.35	134°
	4	0	0	--	--
AMP	5	+ 13.4	--	--	--
	6	+ 90	220K ⑫	2.5	75°
	7	--	1 meg.	0.11	248°
	8	+ 1.0	5600	0.07	248°
	9	--	--	--	--
V-202	1	+110	10K ⑫	1.1	281°
	2	--	1 meg.	1.4	98°
12AU7	3	+ 26	11500	1.2	100°
	4	0	0	--	--
AMP	5	+ 13.4	--	--	--
	6	+ 75	27K ⑪	20	138°
	7	--	1 meg.	2.6	318°
	8	+ 10	1500	1.1	318°
	9	--	--	--	--
V-203	1	+140	0 ⑪	--	--
	2	--	1 meg.	.92	356°
12AU7	3	+ 13	1400	.58	356°
	4	0	0	--	--
CATH-FOL	5	+ 13.4	--	--	--
	6	+140	0 ⑪	--	--
	7	--	480K	.92	266°
	8	+ 13	1400	.58	266°
	9	--	--	--	--
V-204	1	+140	0 ⑪	--	--
	2	--	1 meg.	.92	176°
12AU7	3	+ 13	1400	.58	176°
	4	0	0	--	--
CATH-FOL	5	+ 13.4	--	--	--
	6	+140	0 ⑪	--	--
	7	--	480K	.92	86°
	8	+ 13	1400	.58	86°
	9	--	--	--	--
V-205	1	--	1 meg.	3.0	40°
	2	+ 9	1150	1.1	40°
6BH6	3	+ 6.7	--	--	--
	4	0	0	--	--
OMNI	5	+ 30	27K ⑬	2.2	263°
OUTPUT	6	+135	0 ⑬	--	--
	7	+ 8	1000	1.0	40°
V-206	1	--	1 meg.	0.04	222°
	2	+ 0.5	1500	0.02	222°
6BH6	3	+ 6.7	--	--	--
	4	+ 13.4	--	--	--
AMP	5	+ 32	470K ⑬	3.0	43°
	6	+ 27	1 meg. ⑮	--	--
	7	+ 0.5	1500	0.02	222°
V-207	1	--	27K	.03	345°
	2	--	27K	.03	345°
12AL5	3	+ 13.7	--	--	--
	4	0	0	--	--
RATIO	5	--	150 ⑭	.16	10 kc
DET	6	--	--	--	--
	7	--	160 ⑭	.16	10 kc
V-208	1	--	1 meg.	1.9	10 kc
	2	0	0	--	--
6BH6	3	+ 6.7	--	--	--
	4	+ 13.4	--	--	--
LIMITER	5	+ 8.5	10K	1.2	10 kc
	6	+ 36	220K ⑬	--	--
	7	0	0	--	--

C-4. MODULATOR-POWER UNIT and MARKER BEACON RECEIVER

TUBE	PIN	DC VOLTS ① RECEIVE	DC VOLTS ① TRANSMIT	OHMS ②
V-401	1	0	0	0
	2	+ 1.0 ⑮	0	150
6BH6	3	0	0	0
MARKER	4	+ 6.7	+ 6.7	--
BEACON	5	+140 ⑮	+ 3	0 ⑯
AMPLIFIER	6	+140 ⑮	+ 3	0 ⑯
	7	0	0	0
V-402	1	--	--	1 meg.
	2	0	0	0
6BH6	3	0	0	0
SPEECH	4	+ 6.7	+ 6.7	--
AMPLIFIER	5	+ 70 ⑮	+ 38	500K ⑰
	6	+ 40 ⑮	+ 40	100K
	7	0	0	0
V-403	1	--	--	470K
	2	+ 12.5	+ 10.5	270
6AQ5	3	+ 6.7	+ 6.7	--
AUDIO	4	+ 13.4	+ 13.4	--
OUTPUT	5	+280	+250	500 ⑰
MOD	6	+255	+220	18K ⑰
	7	--	--	470K
X-402	1	0	0	0
	2	+ 13.5	+ 13.4 ⑱	--
	3	--	--	--
	4	+140 ⑮	0	--
	5	0	+275	--
	6	0	+250	400 ⑲
	7	+140	0	250 ⑱
	8	+140	+125	250 ⑱
	9	+135	+120	1250 ⑱
	10	+135	+120	1250 ⑱
	11	+ 70	+ 16	470K ⑰
X-404	1	0	0	0
	2	+ 13.4	+ 13.4	--
	3	--	--	--
	4	+140	0	250 ⑱
	5	+ 70	+ 16	470K ⑰
	6	0	0	0

① Measured with high-impedance voltmeter. Function switch set to VOR.
② Measured to ground, all cables disconnected, except as noted.
⑨ Measured with NARCO T-4 or Ballantine Model 300 with X10 Multiplier.
⑩ Measured with NARCO T-3 Omni-Simulator and T-4 Filter-Voltmeter.
⑪ Measured to pin 8 of X-4.
⑫ Measured to pin 10 of X-4.
⑬ Measured to pin 9 of X-4.
⑭ Measured to terminal E of ratio detector coil.
⑮ Marker beacon switch pulled on.
⑯ Measured to pin 4 of X-402.
⑰ Measured to + terminal of selenium rectifiers.
⑱ Measured to center tap of vibrator transformer secondary.
⑲ Measured to pin 5 of X-402.

D. ACTIVATION OF ADDITIONAL CHANNELS

There are sockets for eight quartz crystals provided in the transmitter, but it is usually supplied with only two crystals. The remainder of the crystals may be procured at a later date to activate all eight channels. These crystals should be plugged in the sockets as shown in Figure 12. Alteration of the factory circuit alignment should not be necessary to accomodate the new crystals. It is well to check operation on all activated channels after installing crystals.

E. OMNI COMPENSATION

The omni circuits are carefully compensated at the factory, and should not require subsequent compensation unless certain critical components have been replaced. The following plan of compensation should be followed completely, and in the order given, should it be necessary to perform it, but it is strongly recommended that it not be tampered with unless absolutely necessary, and then only if all the necessary items of special and standard test equipment are used. All compensations must be made in the order shown below.

E-1. RECTIFIER BALANCE

The purpose of this compensation is to balance the two rectifier circuits which form a part of the L-R metering circuit. Unbalance which arises from the manufacturing tolerances of these components will cause a reciprocal error in the bearing readings. A reciprocal error is one which causes the two course selector readings for L-R meter centering to differ by not exactly 180° (±2°). The need for recompensating the rectifier balance is indicated by excessive reciprocal error when test signal is reversed, but not necessarily when the course selector dial is shifted 180°.

1. Connect the LOW R.F. output jack of a NARCO T-3 Omni-Simulator to the receiver antenna receptacle. Tune to the simulated omni signal.
2. Set the FUNCTION SWITCH on VOR, the T-3 switch to OMNI VAR, and the T-3 azimuth dial to 270°.
3. Set the course selector dial of the VTR-1 to center the L-R meter near 270°.
4. Reset the T-3 azimuth dial to 90°. If L-R meter does not recenter between 88° and 90° on the T-3 dial, bridge R-234 or R-235 as needed with shunting resistors to bring this reciprocal test within limits. Repeat steps 3 and 4 for each shunt resistor test. Shunting resistors will usually lie between 5000 and 50000 ohms.
5. Excessive rectifier unbalance results from poorly-matched rectifiers. Replacement matched rectifier pairs can be obtained from the factory. They mount in the clips provided. Avoid excessive heat in soldering to rectifier terminals. It is best to remove the rectifier from the clips to which any soldering is to be done, being careful to replace them exactly as they were.

E-2. PHASE ZERO (270°)

The phase zero adjustment shifts the phase of the reference signal to compensate for accumulated component tolerance errors which would cause a fixed error in the course reading. A fixed error is one which is independent of omni course. Small compensations (up to ±3°) made by means of adjusting R-248 which is shown in Figure 13. Larger compensations (up to ±10°) if required, can be made by substituting other resistor values for R-247. This resistor value has been selected at the factory to approximately center the adjustable resistor at the proper zero phase setting. This one adjustment permits compensation for most of the errors which arise as a result of component drifts (which are held to a practical minimum) and changes in tube characteristics. To make this compensation, proceed as follows:

1. Connect the LOW R.F. output jack of a T-3 Omni-Simulator to the receiver antenna receptacle. Tune to the simulated omni signal.
2. Set the T-3 switch to OMNI VAR, and its azimuth dial to 270°.
3. Set the FUNCTION SWITCH to VOR, and the course selector dial to 270°.
4. Reset R-248, (and R-247 if necessary) to center the L-R meter.

E-3. PHASE INVERTER BALANCE (90°)

The phase inverter balance is compensated after the phase zero is set at 270°. Proceed as follows:

1. Reset the T-3 azimuth dial to 90°.
2. Reset the course selector dial to 90°. If L-R meter will not center between 88° and 92°, the phase inverter balance needs correction.
3. Bridge R-214 with shunting resistors between 1 megohm and 50 megohms as needed to correct 90° readings.
4. If shunting R-214 increases the error, and in the same direction, repeat E-2 steps using 90° as the course settings, and then E-3 using 270° as the course settings, and then E-3 using 270° as the course settings, but shunting R-215 as needed.

E-4. PHASE BRIDGE BALANCE (0°)

1. Reset the T-3 azimuth dial to 0°.
2. Reset the course selector dial to 0°. If L-R meter will not center between 358° and 2°, the phase bridge needs compensation.
3. Shunt R-217 or C-210 as needed to center the L-R meter at 0°. Resistor values should lie between 5 megohms and 50 megohms, and capacitor values between 100 MMF and 470 MMF.

E-5. PHASE BRIDGE BALANCE (180°)

Repeat same procedure as in E-4, but set dials to 180°. Normal tolerance is ±2°.

Components to be shunted are R-218 or C-211.

F. CRITICAL COMPONENTS

F-1. TUBES

The various tubes used in this equipment are not selected, or critical, except that they must lie within ±20% of the rated transconductance if full performance is to be achieved.

The four sections of the two cathode follower tubes (V-203 and V-204) must be matched to within ±20% in transconductance in order to maintain the close balance between the four cathode output voltages. Most good tubes will lie well within these limits, but if excessive unbalance is evident from the tests outlined, replacement tubes should be tried, until a suitable one is found. It is well to check these four voltages for balance of the regular maintenance inspections, at which time any replacements can be made. In the event that a pair of tubes having transconductances lying within the above matching tolerance cannot be obtained locally, a properly matched pair can be obtained from the factory.

F-2. CAPACITORS and RESISTORS

The following capacitors and resistors have special characteristics, and should be replaced by identical units obtainable from the factory.

C-111, 201, 202, 203, 204, 205, 206, 207, 210, 211, 212, 215, 218.

R-201, 202, 203, 204, 205, 208, 209, 211, 212, 217, 218, 219, 220, 221, 222, 225, 226, 234, 235, 236, 237, 248.

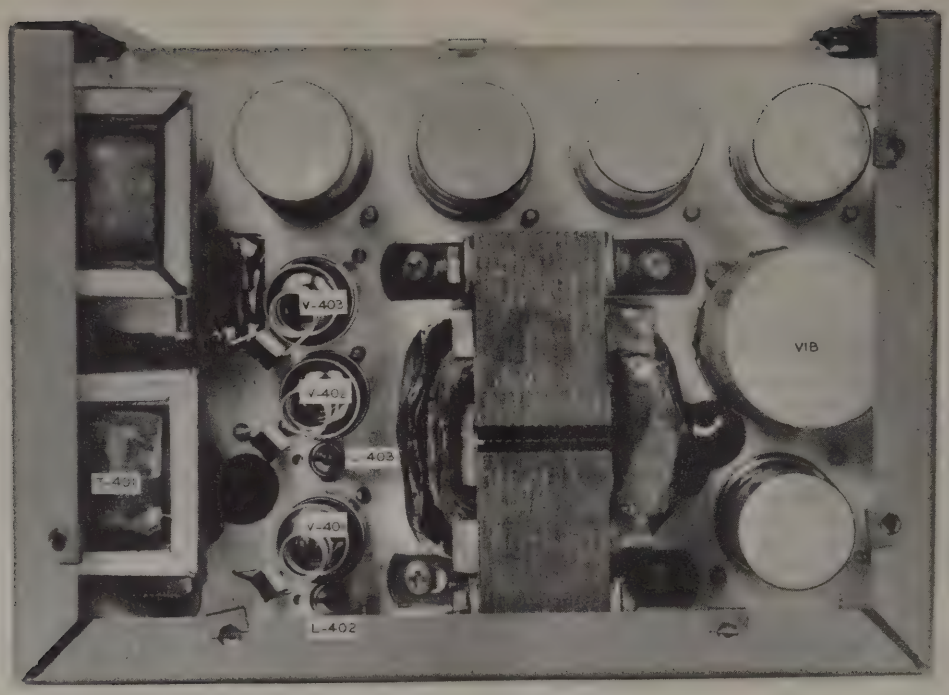


Figure 15 · POWER UNIT · TOP VIEW

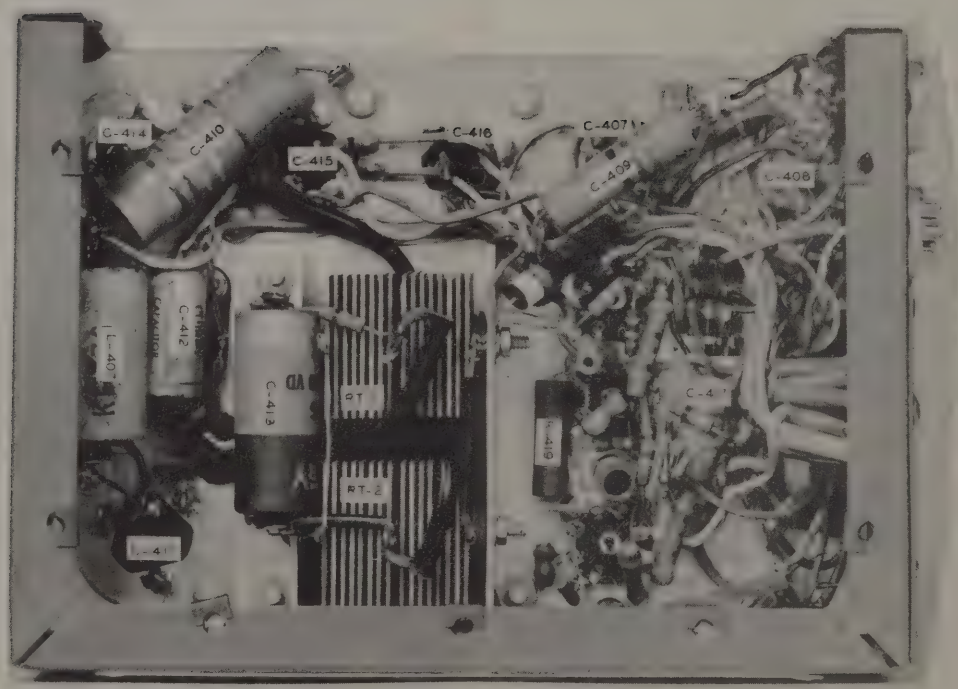


Figure 16 · POWER UNIT · BOTTOM VIEW

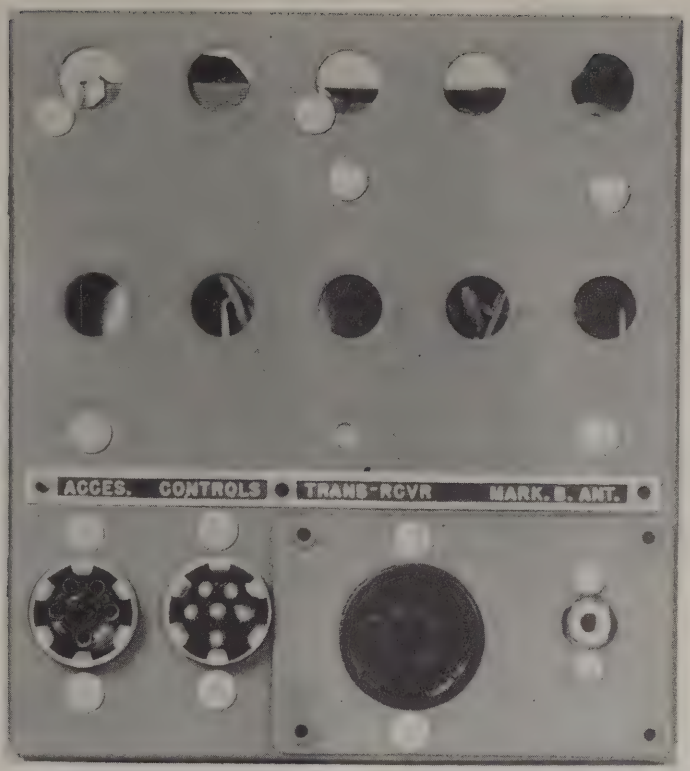


Figure 17 · POWER UNIT · END VIEW

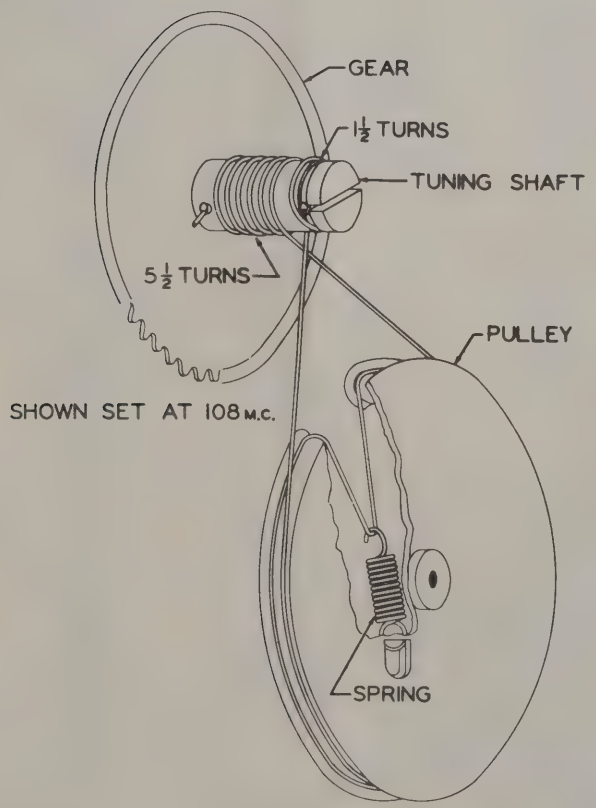


Figure 9 · DIAL STRINGING DIAGRAM

F-3. OMNI OUTPUT TRANSFORMER

As mentioned in Sect. III, D-4, the audio output transformer employed in the variable phase channel is of unusually high quality as regards low-frequency performance(30 cycles). If replacement is required, use only the identical type of unit, which is available from the factory only.

After replacing this transformer, the rectifier balance compensation should be checked and recompensated, if needed, as described in paragraph E-1, and also the phase zero setting as described in paragraph E-2.

F-4. RECTIFIERS (IN34A)

The crystal rectifiers (1N34A) used in the L-R metering circuit (XT-201 and XT-202) are carefully matched at the factory, so as to minimize the balance compensation. This matching is done with a special test bridge.

It is strongly recommended that any replacement 1N34A rectifiers be obtained in matched pairs from the factory. The rectifier load resistors (R-234 and R-235) are held to ±5%. Any replacements should be held to the same tolerance. After replacing a pair of these rectifiers, or one or more of the load resistors, the rectifier balance should be rechecked and recompensated, if necessary, as described in paragraph E-1.

F-5. COURSE SELECTOR

The course selector comprises a special wire-wound potentiometer with 3 accurately-located taps.

The dials are interchangable, but after changing a dial or a potentiometer, the 180° tap must be aligned with the 180° dial mark as follows:

1. Connect a LOW-range ohmmeter to the center arm terminal, and to the 180° tap terminal of the course selector potentiometer. (Points F and G in Figure 14).
2. Set the potentiometer shaft for the lowest ohms reading using a screw driver in the slot provided in the shaft.
3. Holding the shaft in this position, rotate the dial until the 180° mark aligns with the index pointer.
4. Press dial firmly against the friction springs under it, and tighten the set screws.
5. Check proper setting by noting if point of lowest resistance as measured in 1. corresponds exactly to the 180° dial reading. If slightly in error, the two screws which hold the pointer can be loosened, and the pointer moved to accurately align it. Retighten screws after alignment.

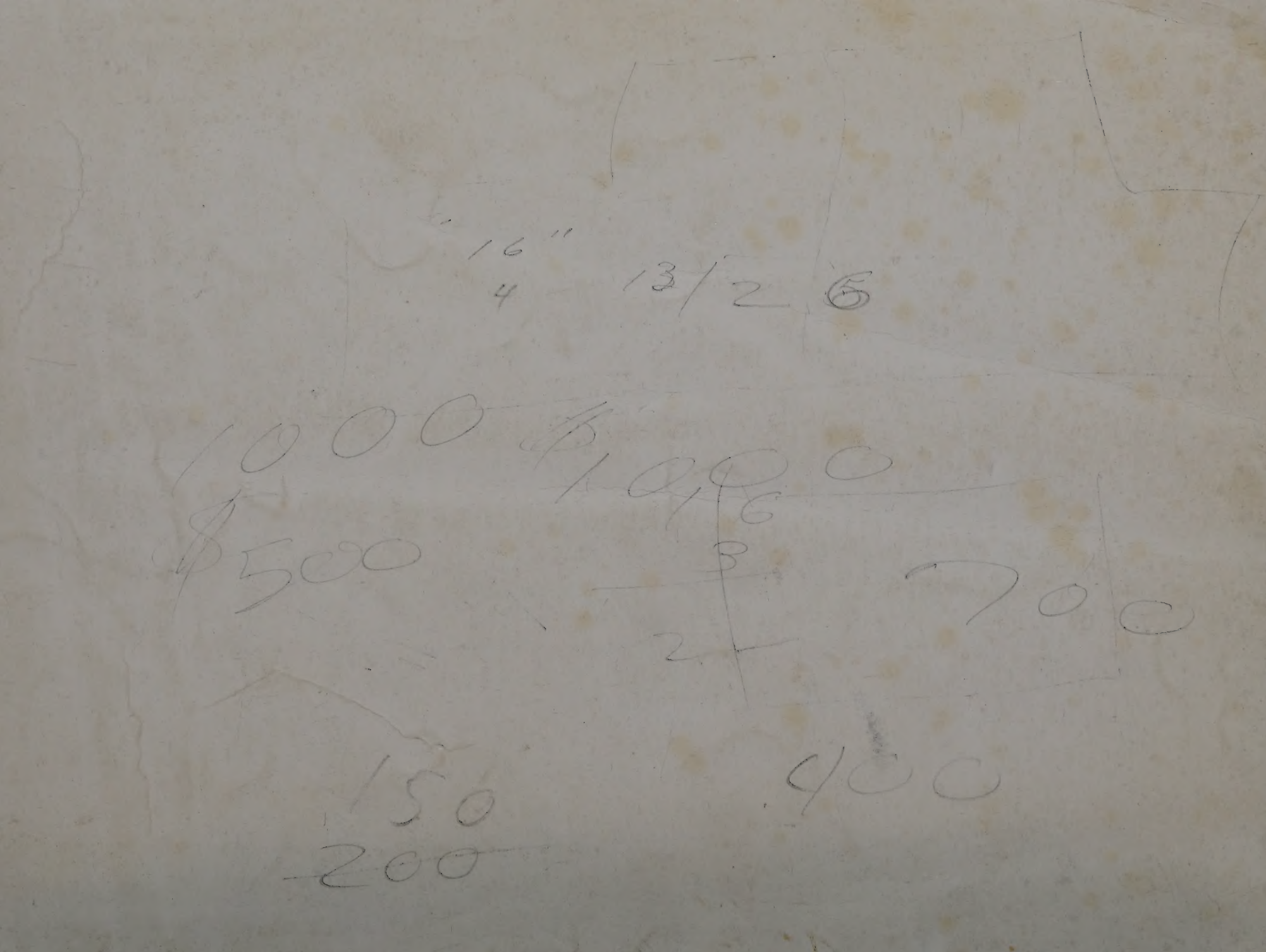
   It is advisable to check the compensations in paragraphs E-2, E-4 and E-5, since these are also used to compensate for slight variations in course selector potentiometers.

G. REPLACEMENT PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
C-101, 102, 103, 104	K-22001-525	Capacitor, Ceramic Trimmer 5-25 Mmf.
C-108	K-21131-019	" " 500 volts 1.0 "
C-301	K-21201-479	" " " " NPO 4.7 "
C-111	K-21207-479	" " " " N750 4.7 "
C-311	K-21201-689	" " " " NPO 6.8 "
C-109, 112	K-21201-220	" " " " " 22 "
C-105, 106, 123, 124, 125	K-21208-101	" " " " GP 100 "
C-230, 231	K-21208-221	" " " " " 220 "
C-107, 128, 302-9, 401	K-21208-471	" " " " " 470 "
C-310	K-21143-471	" " 1000 " " 470 "
C-113, 114, 115, 117, 402, 403, 404, 405, 406	K-21217-302	" " 500 " " 3000 "
C-201, 202, 204, 205, 206, 207, 212	K-21117-512	" Mica " " ±2% 5100 "
C-203, 210, 211, 225	K-21118-1022	" " 300 " " 10200 "
C-409	K-21155-682	" Tubular 600 " .0068 MFD
C-110, 116, 118, 120, 136, 137, 138, 126	K-21163-103	" " 200 " (midget) .01 "
C-121, 130, 229, 232	K-21153-103	" " 400 " .01 "
C-224	K-21152-123	" " 200 " .012 "
C-413	K-21161-203	" Oil 1600 " .02 "
C-222, 223, 226, 227	K-21152-473	" Tubular 200 " .047 "
C-119, 122, 129, 131, 132, 208, 209, 213, 219, 221	K-21152-104	" " " " .1 "
C-410	K-21151-224	" " " " .22 "
C-133	K-21152-334	" " " " .33 "
C-220	K-21152-474	" " " " .47 "
C-214	K-21163-504	" " " " (midget) .5 "
C-412	K-21163-105	" " " " 1.0 "
C-217, 218	K-21510-550	" Electrolytic 50 " 5 "
C-407	K-21522-151510	" " 450 " 15-15-10 "
C-408	K-21514-202020	" " 25 " 20-20-20 "
C-228	K-21510-506	" " 6 " 50 "
C-415, 416	K-21517-5050	" " 150 " 50-50 "
C-217	K-21535-50	" " 350 " 50 "
C-414	K-21517-100	" " 150 " 100 "
C-134	K-21526-500	" " .1 " NP 500 "
C-411	K-21514-500	" " 25 " " "
C-216	K-21528-1000	" " 15 " 1000 "
C-215	K-21511-2000	" " .1 " NP 2000 "

SYMBOL	PART NO.	DESCRIPTION
L-101 to L-105	M-51766	Tuning Coil Assembly (with Trimmers)
L-106, 109-112, 122	K-11138-2	R.F. Choke Coil
L-107, 108	K-11175	Inductor, Tone Filter
L-301	K-11202	Oscillator Coil Assembly
L-302	K-11201	Doubler Coil Assembly
L-303, 304, 305	K-11203	Output Coil Assembly
L-401, 402	K-11204	Marker Beacon Input Coil Assembly
L-403, 404	K-11205	Marker Beacon Output Coil Assembly
L-405, 406	K-11173-1	Filter Choke, 4 hy.
L-407	K-11174-1	Hash Choke
LM-1	--	Panel Lamp, Mazda No. 49
LM-2	--	Panel Lamp, Mazda No. 51
M-201	--	Left-Right Meter
M-202	--	To-From Meter
--	M-2	External Left-Right Meter
R-102, 103, 109, 110, 113, 240, 304, 305, 308, 309, 401	K-31110-151	Resistor, Carbon, 1/2 watt, 150 ohms, ±10%
R-234, 235, 236, 237	K-31117-331	" Wire, " 330 " ±5%
R-233	K-31110-561	" Carbon, " 560 " ±10%
R-104, 107, 112, 114, 122, 402, 403, 404, 415	K-31110-471	" " " 470 " "
R-129, 241, 417, 418	K-31110-102	" " " 1,000 " "
R-210, 230, 244	K-31110-152	" " " 1,500 " "
R-219, 220, 221, 222	K-31115-332	" " " 3,300 " ±5%
R-106, 133, 227, 238	K-31110-332	" " " 3,300 " ±10%
R-232	K-31110-154	" " " 150,000 " "
R-206	K-31110-562	" " " 5,600 " "
R-123	K-31110-682	" " " 6,800 " "
R-211, 212	K-31130-103	" " " 10,000 " ±1%
R-108, 111, 116, 131, 216, 306, 251	K-31110-103	" " " 10,000 " ±10%
R-413	K-31110-183	" " " 18,000 " "
R-224, 231, 239, 249, 250, 414	K-31110-273	" " " 27,000 " "
R-120, 121, 130, 307	K-31110-473	" " " 47,000 " "
R-302	K-31110-563	" " " 56,000 " "
R-101, 105, 119, 213, 223, 228, 252, 255, 301, 303	K-31110-104	" " " 100,000 " "
R-207, 256	K-31110-224	" " " 220,000 " "
R-201	K-31122-264	" " " 260,000 " ±1%
R-214, 215, 243, 408, 409, 410, 411	K-31110-474	" " " 470,000 " ±10%
R-202, 203, 217, 218	K-31122-524	" " " 520,000 " ±1%
R-115, 117, 118, 125, 126, 127, 128, 229, 242, 245, 246, 253, 254, 405, 407	K-31110-105	" " " 1 Meg. ±10%
R-204, 205, 208, 209, 226	K-31122-1044	" " " 1.04 " ±1%
R-310	K-31125-129	" Wire, 1 watt, 1.2 ohms ±10%
R-416	K-31125-470	" " " 47 " "
R-412	K-31113-271	" Carbon, " 270 " "
R-134	K-31121-470	" Wire, 2 watts 47 "
R-419	K-31118-420	" " 4 " 42 "
R-132	K-32007-103	Potentiometer, 10,000 ohms linear taper
R-225	K-32004-2	" 10,000 " (course selector)
R-428	K-32006-253	" 25,000 " linear taper
R-124	K-32001-1	" 1 Meg. audio taper
RT-1, RT-2	M-51806	Rectifier Assembly, Selenium
RY-1	K-65113-1	Relay
S-1	K-61115	Switch, Rotary, function
S-2	K-61116	" " crystal
S-3	K-61118	" Push-pull, Marker Beacon
T-101, 102, 103, 104	K-11162-2	Transformer, I.F., 10.7 mc.
T-201	M-11171-2	" Omni Output
T-202	K-11170	" Ratio Detector
T-401	K-11166	" Audio Output
T-402	K-11167	" Vibrator

SYMBOL	PART NO.	DESCRIPTION
V-101 to 106, 109, 205, 206, 208, 301, 401, 402	--	Tube, 6BH6
V-107	--	" 6AQ6
V-108, 207	--	" 12AL5
V-201	--	" 12AX7
V-202, 203, 204	--	" 12AU7
V-302, 303	--	" 5763
V-403	--	" 6AQ5
VIB	K-64003	Vibrator, 12-volt, 115 cycles
X-1	K-41143	Receptacle, Receiver Antenna
X-2, 401	K-41110-2	" Transmitter and Marker Beacon Antenna
X-3	K-41115-S3S	" External Meter
X-4	K-41144-11	Connector, 11-pin male
X-402	K-41126-11	Receptacle, 11-pin
X-403	K-41112-6M	" 6-pin male
X-404	K-41112-6F	" 6-pin female
--	K-42002-1	Tube Socket, 7-pin miniature, bakelite
--	K-42002-2	" " " " ceramic
--	K-42003-1	" " 9-pin " bakelite
--	K-42002-3	" " " " low loss
--	K-42004-4	" " 4-pin wafer (vibrator)
--	K-41145	Lamp Socket, pilot
XT-201, 202	K-75002-2	Crystal Rectifiers, 1N34A, matched pair
XT-101, 102, 203, 204	K-75002-1	" " "
XT-301	K-72002-1	Crystal, Quartz, for 121.5 mc. (EMER)
XT-302	K-72002-2	" " " 121.7 " (G-7)
XT-303	K-72002-3	" " " 121.9 " (G-9)
XT-304	K-72002-4	" " " 122.1 " (R-1)
XT-305	K-72002-5	" " " 122.3 " (R-3)
XT-306	K-72002-6	" " " 122.5 " (T-5)
XT-307	K-72002-7	" " " 122.7 " (T-7)
XT-308	K-72002-8	" " " 122.9 " (T-9)
XT-309	K-72002-12	" " " 122.8 " (UNICOM)
--	K-41127-1	Jack, Phone
--	K-41128-1	" Mike
--	P-51701	Case, Transmitter-Receiver Unit
--	P-51704	Plastic Panel
--	M-51708	Tuning Crank Assembly
--	K-51713	Knob, Volume Control
--	K-51714	" Marker Switch
--	K-51715	" Pointer type
--	M-51726	Course Selector Dial Assembly
--	K-51730	" " Pointer
--	M-51739	Crystal Socket Assembly
--	M-51749	Tuning Pinion and Stop Washer Assembly
--	P-51716	Trim Panel, metal
--	P-51403-2	Power Unit, L Plate
--	M-51404-1	" " Top Cover Plate
--	K-51808	" " Mounting Bracket
--	M-51809	" " Mounting Plate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